Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

MAY, 1911.

PLANT HAIRS.

By K. E. STYAN.

Introduction.

Just as there is a reason for "all things under the sun," so there is a reason why plants should possess hairs on some of their many organs. They are placed where we find them for a definite purpose, and tiny as they are, these delicate hairs — these purposes are wonderfully carried out! Do not the hairs on nettles, which are long, sharp-pointed, and full of a burning, acrid secretion that "stings" when pierced into one's flesh, help to keep at bay browsing animals, insects, and anyone who tries to do damage to the plants? Does not the dense, webby growth of hairs found on the mulleins and numerous other plants cause an unpleasant sense of choking to anything that tries to eat them, and so acts as a deterrent as would a piece of flannel? Again, the presence of hairs is a guard against the attacks of aphis and other blights of a similar nature, and is also a protection against any excess of drought, or the too fiercely burning rays of the sun. Plants found in very hot, burning situations are often clad in a thick felt-like dress, so that they may check too rapid evaporation of the moisture drunk in by their roots, and so live and thrive in safety. Against any excess of damp and cold a hairy dress is equally protective, and thus we find hairy plants are common in *very* cold localities as well as in *very* hot ones, at very high as well as in low altitudes. So, too, do hairs help a plant to climb and cling; to suck up food (as root-hairs), to disseminate its fruits and seeds, to protect its delicate and essential organs (viz., stamens and pistils), to guard the pores in leaves, and in many other ways to act as most necessary organs essential to the life of the plant. In forming the delicate silky fringes on leaves and stems; the beautiful silvery or coloured hairy appendages on flowers; and the "felt," "web" and woolly coverings of many a plant's surface, Nature made structures of infinite loveliness and strangeness of outline. We may see them, *en masse*, any day, and admire the softness and richness of their make, but it needs the

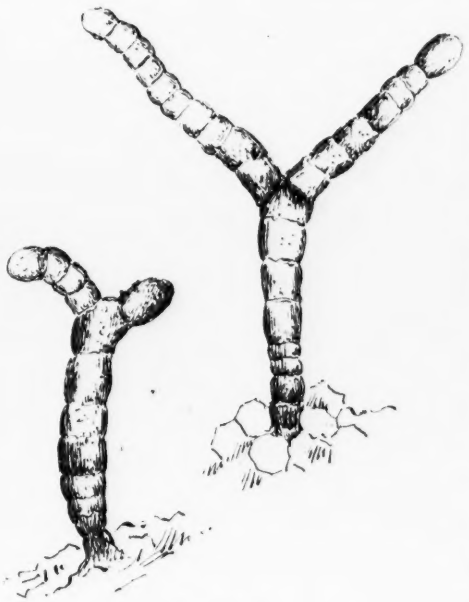

Figure 1.
Forked Hairs from the Corolla of the Vegetable Marrow.

microscope to show us the true loveliness of each individual kind of hair. For there are very many different kinds, and each, in its way, holds some charm; some, too, show choice colours, others emit pleasant or disagreeable odours; some produce oily or viscid exudations, whilst others form secretions with peculiar properties, such as bitter, (*Primula sinensis*), lemony, saltish, sugary and burning (stinging nettle). Some we find are very smooth-coated, others very rough, whilst—internally—one hair may be built up of a number of separate cells, and another may consist of merely one, long and narrow or broad and rounded as the case may be.

If we look at any two hairs, either is different from the other; no two are ever quite alike, and herein lies the absence of all monotony. Each is an object of interest in itself; something truly marvellous, worthy of the closest scrutiny we can bestow upon it.

Amongst the many different kinds met with, the following are the principal:—(1) Forked, (2) Hooked, (3) Glandular, (4) Branched, (5) Stinging, (6) Stellate, (7) Peltate, (8) Jointed, though, perhaps, those known as *Root-hairs* should be considered chief of all, since they are, truly, the means by which a plant derives its food from the soil in which it grows, and is able to perform its life's functions. They are the most *useful*, though their lives are very brief, and, at the same time, some of the most simple in form that can be met with anywhere.

I.—Forked and Hooked Hairs.

Forked, or, as they are also called, *barbed* hairs are often extremely curious as well as beautiful in form and are very frequently met with on plant surfaces. Their distinctive feature is, that the hair pedicel, or stem, terminates in two or more prongs which are sometimes thick and rounded at the tips, but most often very sharp-pointed: sometimes, too, they are quite erect in position, whilst at others they become curved.

Some quaint examples may be seen in the accompanying illustrations. Figure 1 shows forked hairs found on the blossom of vegetable-marrow. It may be noticed that the hair consists of a number of thick cells placed one on top of the other till quite a long pedicel is formed, and then that the pedicel divides off into two thick branches, or prongs. In the smaller hair illustrated, it will be seen that the prongs are being formed.

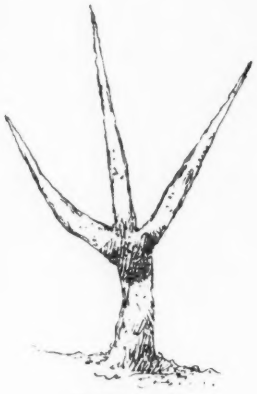

FIGURE 2.
Forked Hairs from the Stem of the Garden *Aubretia*.

Figure 3 represents barbed hairs that abound on the leaves of our Wild Rough Hawk-bit. Each prong will be seen to be *very* sharp-pointed. Figure 2 is a specially pretty example of a three-pronged hair from the stem of *Aubretia*, a plant so favoured in our rock-gardens and rock edges of borders. The way in which the sharp prongs spread out from the tip of a somewhat short, thick stem, is very suggestive of a fork.

Hooked hairs are also known as curved or saw-like, and are found largely on climbing plants and those that, whilst not being in the true sense climbers, straggle up hedgeways, and in and out of the undergrowth of copses. They are very useful to such plants, for they act as small grappling irons and readily catch on to any foreign supports.

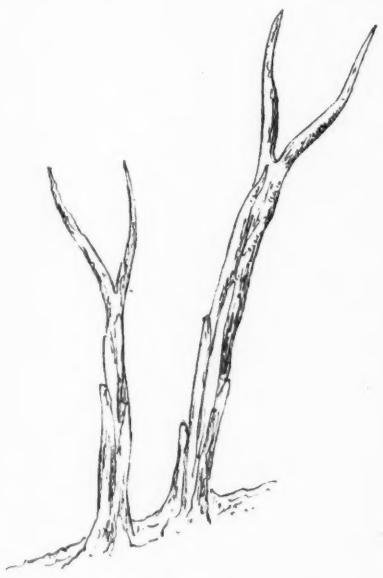

FIGURE 3.
Forked Hairs from the Leaf of Rough Hawk-bit.

Figure 4 shows curved hairs found on the leaf of the garden scarlet-runner bean. They are beautiful little structures and most useful as climbing supports, tiny though they are. Figure 6 represents the saw-like hairs found on every surface, stem, leaf and flower of wild Cleavers; a plant that grows in rank luxuriance in most of our hedges and copses; a "weed" that often causes great annoyance by the persistent way in which it clings to one's own clothing when wandering along the countryside. Strange, indeed, are the hooked hairs met with on wild Hop (see Figure 5), another climbing plant of English hedgerows. On stem and leaf these curious hairs abound, and one needs only to see their formidable appearance to understand why it is that in wet weather (when the hairs are specially stiff), if hop-picking, or wandering carelessly between the hanging sprays in a hop-garden, one's skin becomes so terribly torn: the hooked hairs are really able to tear and cause great

soreness to hands and face. Each hair is bulbous, or swollen at the base, and gives off one or two curved arms at its apex: when two are present the whole structure has the appearance of a bull's head. Many hooked hairs are very rough to the touch, their upper cells showing excrescences of various kinds; these are also useful adjuncts to the plant for climbing purposes.

FIGURE 4.
Hooked Hairs from the Stem of the Scarlet Runner Bean.

II.—GLANDULAR PLANT HAIRS.

Amongst this class of hairs—one of the most numerous of all—are found structures of the most varying types.

A typical glandular hair consists of a more or less swollen base, a pedicel that is either long or short, and, at the tip of this, a head—or cap—that assumes in different plant species a great variety of shapes. In some plants it is oval (White Campion), in others triangular (Speedwell), and very frequently indeed it is circular. In this cap, or head, are secreted oils, irritant juices (*Primula obconica*), resins, gums, and peptonising digestive fluids, as the case may be, to whose presence are due the varying colours, odours and flavours met with amongst plant-hairs. These properties are useful in attracting or warding off welcome or unwelcome insect visitors, in catching and digesting insects (as do the tentacular hairs on Wild Sundew and other insectivorous plants that *live* on the food trapped and digested by their hairs), also in protecting young buds whilst developing.

FIGURE 5.
Hooked Hairs from the Stem of the Wild Hop.

The hairs that play such an important part in doing this latter work are peculiar glandular ones called *colleters* that are present on leaf-buds, and, after rapidly maturing, usually die away as soon as the bud really begins to open. They secrete a watery gum mucilage, together with drops of resin or balsam, which become laid over the surface of the bud, thus forming a protection for the delicate structure they guard. In Ribes, Salvia and Honeysuckle, gum is largely present in the colleters. Many plants show more than one kind of hair on the same structure, each kind having its own special function to perform. Thus the Marsh Avens produces a tiny fruit (achene) that is provided with a feathery awn. This awn shows two distinct forms of hairs:—(1) beautiful slender, long silky ones, that easily catch the wind, that wafts the fruit about. (2) glandular ones that are extremely sticky: these help the wee fruit to *adhere* to anything with which it may come into contact.

Beautiful beyond all description are the glandular hairs on the Sundew, nor can anyone who has ever seen a mass of these plants, growing on a large area of bog-land, ever forget the sight of the reddish-hued hairs glistening and sparkling in the sunlight like vast myriads of diamonds. Each hair tip (when in a state of quiescence) shows a bead of silvery, shining secretion, and the effect of this, as a sunbeam streams across it, is one of infinite charm. In the accompanying illustrations are some glandular hairs often met with. Figure 10 shows triangular-headed hairs from the leaf of *Atriplex patula*—a common "weed." Figure 11 is a very much magnified hair from the calyx of Purple Dead Nettle, showing the many cells and circular tip with which the hair is built up. Figure 9 are quaint hairs from the sepals of Sweet Pea. These hairs are extremely bulbous at the base, but very long and slender above, and they bear no "cap" at the tip of the pedicel. In the swollen base, full of glands, the secretions are formed. Figure 8, showing hairs from the stem of London Pride, is well worth studying, for the microscope can hardly show any hair groups more lovely than those found on this plant. One may liken them to rows of long, slender, silvery-hued, stemmed goblets, springing from a slightly spreading stand, and ending in a circular bowl filled with a rich ruby-coloured wine. The whole plant is covered with these exquisite little forms. In Figure 7 are seen the curious hairs from the leaf of White Bryony: note the curious glandular tips composed of many cells. Figure 12, too, is very remarkable. The leaves of *Arctotis* are covered with a thick "felt," and under a microscope we find that this is made up of a mass of slender intertwining thread-like hairs, whose bases

FIGURE 6.
Hooked Hairs from the Stem of Cleavers.

differ. One kind of hair is circular and glandular below, and the other, long and brick-like. The tips of each give off a very long thread that turns in and out, interweaves, and forms the "felt" we see and admire so much even with the naked eye.

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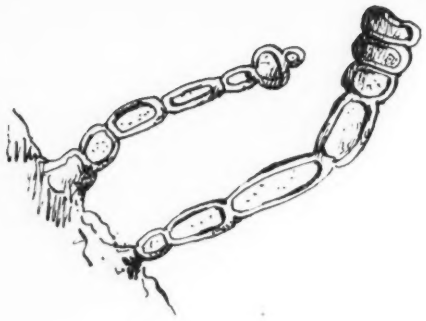

FIGURE 7.
From the Leaf of White Bryony.

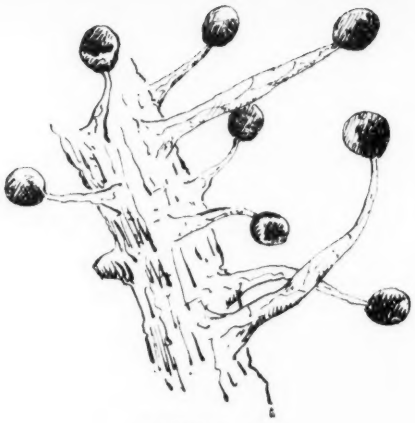

FIGURE 8.
From the Stem of London Pride.

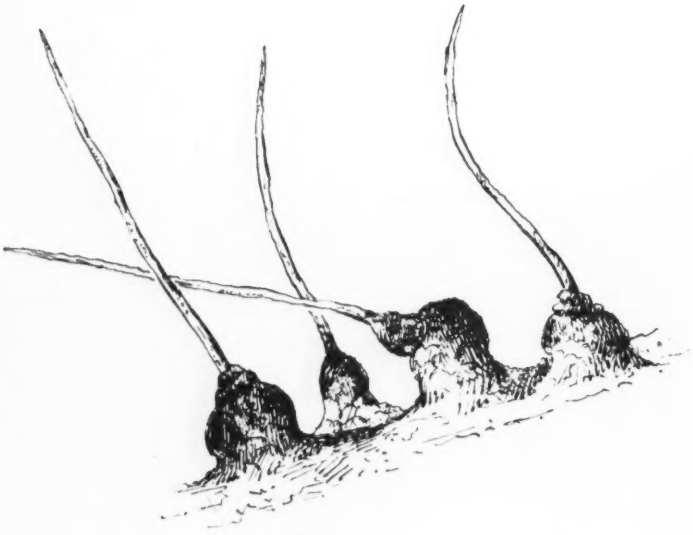

FIGURE 9.
From the Sepals of the Sweet Pea.

FIGURE 10.
From the Leaf of *Atriplex patula*.

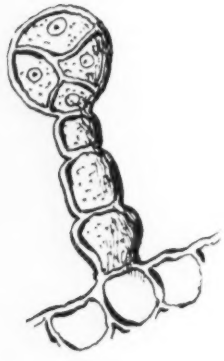

FIGURE 11.
From the calyx of the
Purple Dead Nettle.

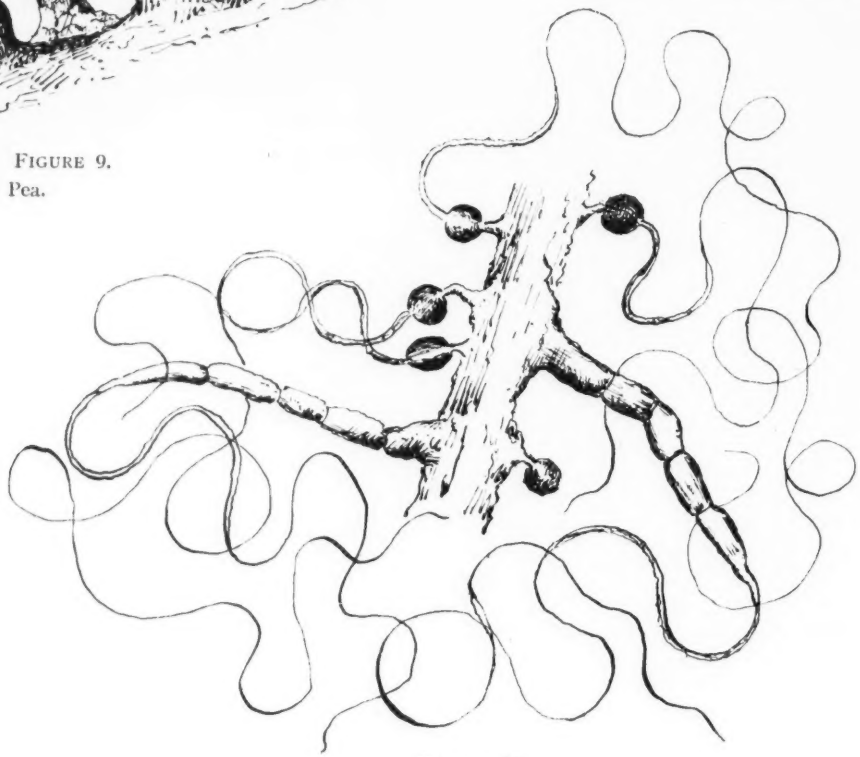

FIGURE 12.
From the "felt" of the Leaf of *Arctotis breviscarba*.

(To be continued.)

EUTECTICS.

By J. E. W. RHODES, Assoc. Inst. M.E..

It has long been known that most alloys melt at lower temperatures than their constituent metals.

Thus solder containing 32 per cent. of lead and 68 per cent. of tin melts at a lower temperature than either tin or lead; and fusible alloys consisting of lead, tin, bismuth, and sometimes cadmium, melt readily in hot water.

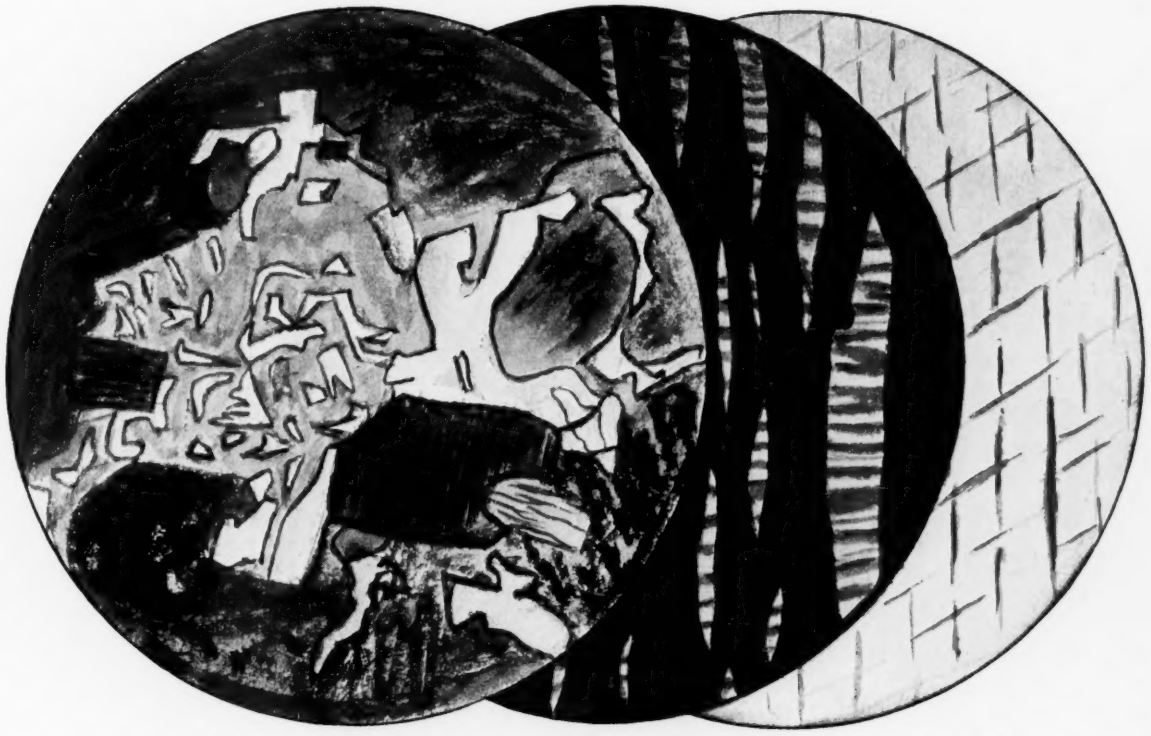

Figure 1.
Micropegmatite in dioritic granophyre.

Figure 2.
Perthite parallel to basal plane.

Figure 3.
Perthite parallel to clinopinacoid.

The same principle has been found to apply to salts: thus fusion mixture consisting of sodium and potassium carbonates in molecular proportions melts much more readily than either of them. The use of fluxes in metallurgy frequently furnishes another instance, so that we may regard the fusion of alumina in presence of cryolite as due to a similar lowering of melting-point.

Let us now take up the study of the tin-lead alloys and plot out the melting points against the percentage of tin. We find our curve consists of two branches with a cusp shown at A in Figure 4. The increase in the percentage of tin continuously lowers the melting-point until A is reached at 180° C and 68 per cent. of tin after which the melting-point rises continuously. This point is called the *eutectic* point and the alloy the eutectic alloy.

The question now arises as to why this alloy should possess such peculiar properties. Is it a chemical compound, since it possesses definite composition and melting-point? To this we can say no at once, for every chemical and electrical test shews that the eutectic contains free lead, free tin, and nothing else. To solve the difficulty the microscope is brought into use. It is at once seen that of all the alloys the eutectic is the only one that is homogeneous; all the others consist of more or less perfect crystals imbedded in a fine grained matrix identical with the eutectic.

It is now easier to understand the phenomenon.

Taking an alloy fairly rich in lead, X in Figure 4, we see that as the temperature falls no crystallisation occurs till we reach a point Y on the curve when pure lead separates out and the temperature falls along the line YA. When A is reached all the lead over and above eutectic proportions has crystallised out and the tin and lead remaining crystallise simultaneously. A eutectic point is therefore the point at which two substances crystallise simultaneously. Now if this occurs, obviously each

substance will interfere with each other's crystallisation, so that we shall get a mass in which the component crystals are very intimately intergrown.

Let us now turn from alloys to the applications of this theory to the crystallisation of rocks.

Few rocks have been synthesised, but many rock-forming minerals have been crystallised from slags, and Vogt has successfully tackled the determination of some of their eutectics. Thus he has found that 68 parts of augite to 32 of olivine form a eutectic, and so do 70 parts of plagioclase felspar to 30 of olivine. And this has been proved to hold in the igneous rocks, for Harker has shewn that in allivalite (a rock composed of olivine and the lime-bearing plagioclase anorthite) the anorthite always crystallised first when constituting more than 70 per cent. of the rock, otherwise the olivine crystallised first.

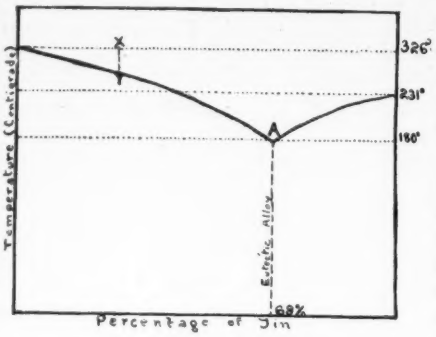

FIGURE 4. Tin-lead Alloys.

In 1888, Teall suggested that the curious intergrowth of quartz and felspar known as micropegmatite was a eutectic, and Vogt shewed from a chemical analysis that the ratios of quartz to felspar in micropegmatite was 26 to 74.

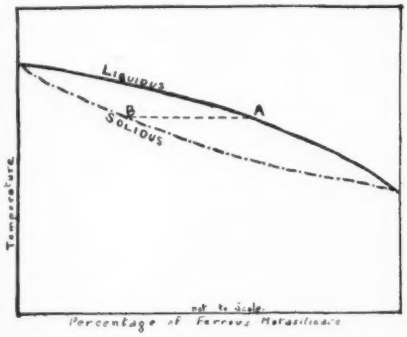

FIGURE 5. Roozeboom's Type I.

Hitherto we have been restricting ourselves to substances which do not shew any crystallographic relationship. We must now examine the melting-point curves of isomorphous mixtures and touch upon the investigations of Bakhuis Roozeboom. He found that the curves fell into five groups, of which only two need at present be examined. Taking the enstatite-hypersthene series of isomorphous metasilicates, where crystals of every possible composition can be obtained, he found that instead of one he obtained two curves, the freezing-point curve or *liquidus*, and the melting-point curve or *solidus*. Thus a liquid of the composition A gives rise to crystals of the composition B, since crystals of the composition A would have melted at this temperature. This curve (shewn in Figure 5) constitutes his Type I. Instances, however, are frequent of imperfect isomorphism in which one constituent, X, will only hold a certain amount of the other, Y, just as ether and water will only mix in certain proportions. This imperfect isomorphism gives rise to Type IV, shewn in Figure 6, where the upper curve, the *liquidus*, is seen to have a eutectic point formed not of the substances but of the mixed crystals A and B, each of which contains both constituents. This has a very interesting application in the case of perthite, a peculiar intergrowth of orthoclase and plagioclase. Orthoclase may contain up to a certain percentage of albite, being then known as soda orthoclase, whilst albite may likewise contain a limited amount of orthoclase. This is because orthoclase being monoclinic and plagioclase triclinic, perfect isomorphism is impossible; nevertheless the relationship is both chemically and crystallographically so close that small amounts of one can form mixed crystals with the other.

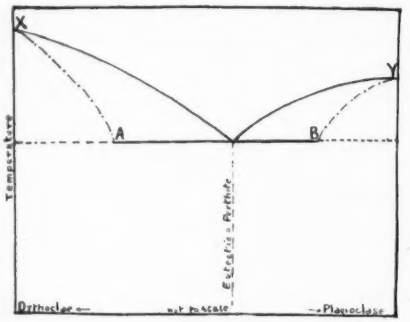

FIGURE 6. Roozeboom's Type IV.

The importance of eutectics in rock formation is very great and the conditions are often very complicated, there being frequently several successive eutectics between different pairs of minerals. A condensed account of the crystallisation of a granophyre may give some idea of the rôle of the eutectic. The rock to be described consists of ferromagnesian metasilicates which crystallise out as augite, alumino-alkali anhydrosilicates which form felspar, and quartz. The augite first separates out in well-formed crystals; then the felspar builds large more or less perfect crystals termed phenocrysts, until the eutectic composition is reached, when the felspar and quartz remaining solidify as micropegmatite, whose felspar is in optical continuity with the phenocrysts.

Besides these micropegmatitic or granophyric rocks, there are many whose ground-mass is too fine to be resolved by the microscope, but has been shewn chemically to be nearly eutectic in composition. Spherulites of minute radiating fibres are found in them, and these have been shewn in some cases to consist of micropegmatite. Hence this ground-mass has been supposed to represent the eutectic on a cryptocrystalline scale, and is termed amphi-eutectic, that is, almost eutectic.

It only remains to add that a classification of rocks has been seriously proposed on the nature of their eutectics. Its advocates regard the eutectic as the dominant feature of the rock. It is being vigorously opposed by the school of petrologists who place chemical composition first; but time alone can decide between them.

By kind permission of the Director of the National Physical Laboratory.

FIGURE 1. The Experimental Basin and Carriage for towing Models.

THE NATIONAL EXPERIMENTAL TANK.

WORK AT THE NATIONAL PHYSICAL LABORATORY.

By E. S. GREW.

AT last the National Experimental Tank, which public subscription and private benefaction have set up within the precincts of the National Physical Laboratory, Bushy Park, is completed; its equipment is undergoing test: and within a very short time the shipbuilding industry of Great Britain will be served by an instrument of precision unsurpassed in any other country. Speaking roughly, one may say that an experimental tank is designed to test the resistance which is offered by the hulls of ships to passage through the water. The desired knowledge is obtained by towing wax models of hulls of given shape and dimensions through the water of the tank, and (after their resistance to towing has been ascertained by the most refined methods of measurement) by converting the results thus arrived at into terms of the larger hulls of iron, wood or steel which the models represent. The National Experimental Tank is intended for much more recondite experiments than are indicated in the foregoing sentence; but the uses of such experiments — which are constantly being made in the experimental tanks of the German shipbuilders, as well as in the tank belonging to Messrs. Denny, of Dumbarton, and in the naval yards of the great Powers—may be readily made clear.

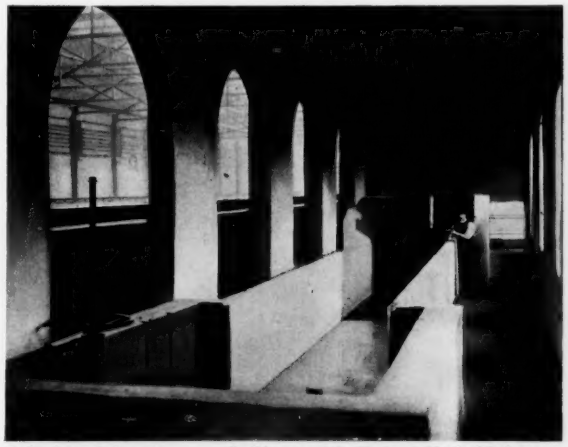

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FIGURE 2.

Small Tank to be used for experiments with the water flowing past the Model, the latter being held in a fixed position.

Let us consider, for example, some of the problems which confront the designer of a torpedo-boat destroyer. He has first of all to derive a high speed from his craft. But he cannot put in as much engine power as he pleases, because that plan may result in an undue weakening of the hull, or in sinking the hull too low in the water, or in depriving the vessel of the necessary room for armament or accommodation.

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Therefore his designs are limited in various directions, and it is only by slight alterations in the shape or in the flotation lines of the hull that he can expect to lessen its resistance to the water through which it is to be driven. The effect of these alterations can be tried, of course, by building a large number of vessels; but evidently the cheaper way, if it is equally trustworthy, will be to experiment with various types of models, which being made (for example) of wax, can actually be altered to different shapes.

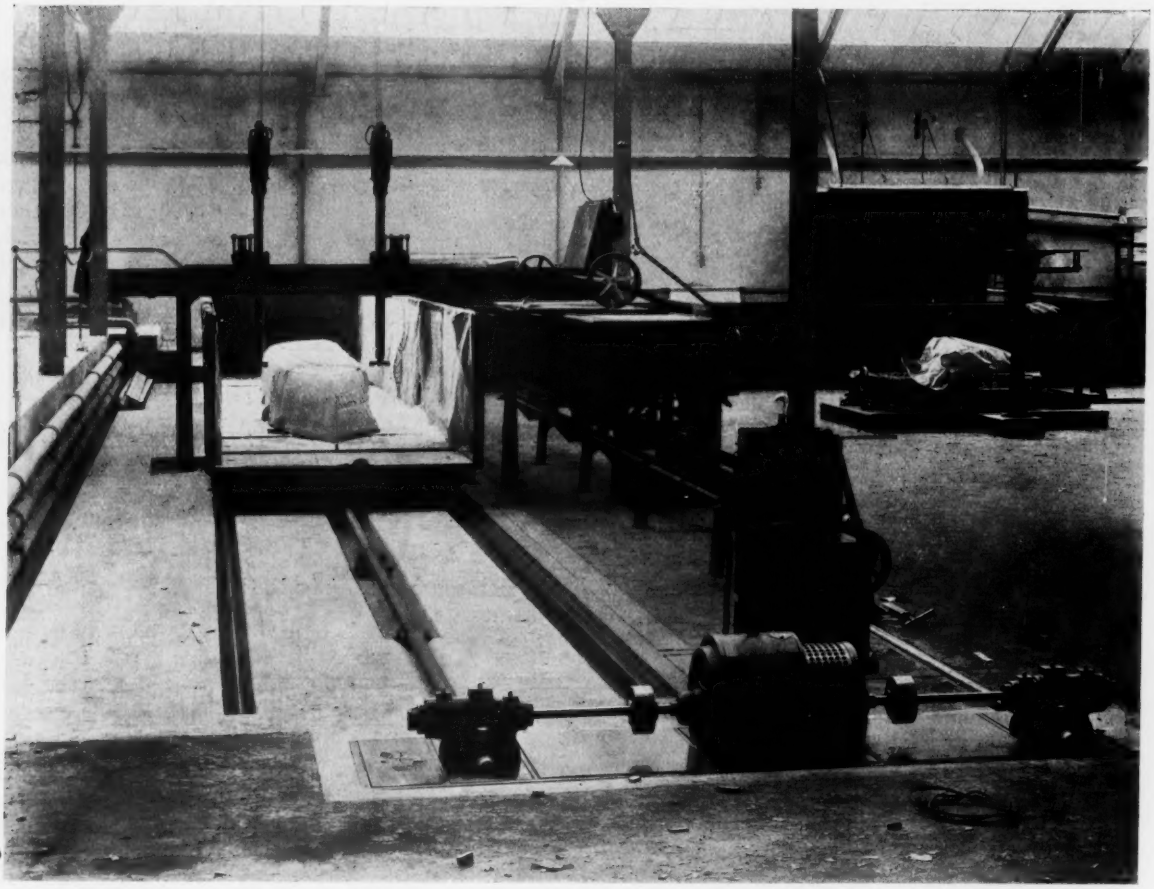

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FIGURE 3. Model-making Apparatus.

The larger the vessel of which the most desirable shape has to be ascertained, the more numerous the difficulties. All sorts of new factors of resistance to passage through the water are introduced. The hull of an ocean liner, or an ocean tramp, or a cruiser, is not smooth. It is studded with bilge-keels, pitted with shaft-escapes, and has other openings and projections in its sunken sides. The rudder, as it moves, causes resistance; and the rudder has to be protected. The propellers also exercise, by their shape and resistance, a considerable effect on the vessel's speed. One may think of the resistance offered by a ship's hull against its forward movement through the water as being composed of a frictional resistance and a wave- and eddy-making resistance. The first kind of resistance is brought about by the friction of the immersed surface of the ship's hull with the water; the second by the formation of waves at the bows and of waves and eddies around the stern.

These coëfficients can be found empirically by the aid of the wax models. The frictional resistance depends on the size and nature of the immersed surface, on the density of the water, and on the speed at which the ship or its model is driven or towed. As the frictional coëfficients for the different kinds of surfaces of ship and model are known — they vary not only with the nature but the lengths of the immersed surfaces—the frictional resistance may be ascertained mathematically without difficulty. If the

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FIGURE 4. General View of the Experimental Tank.

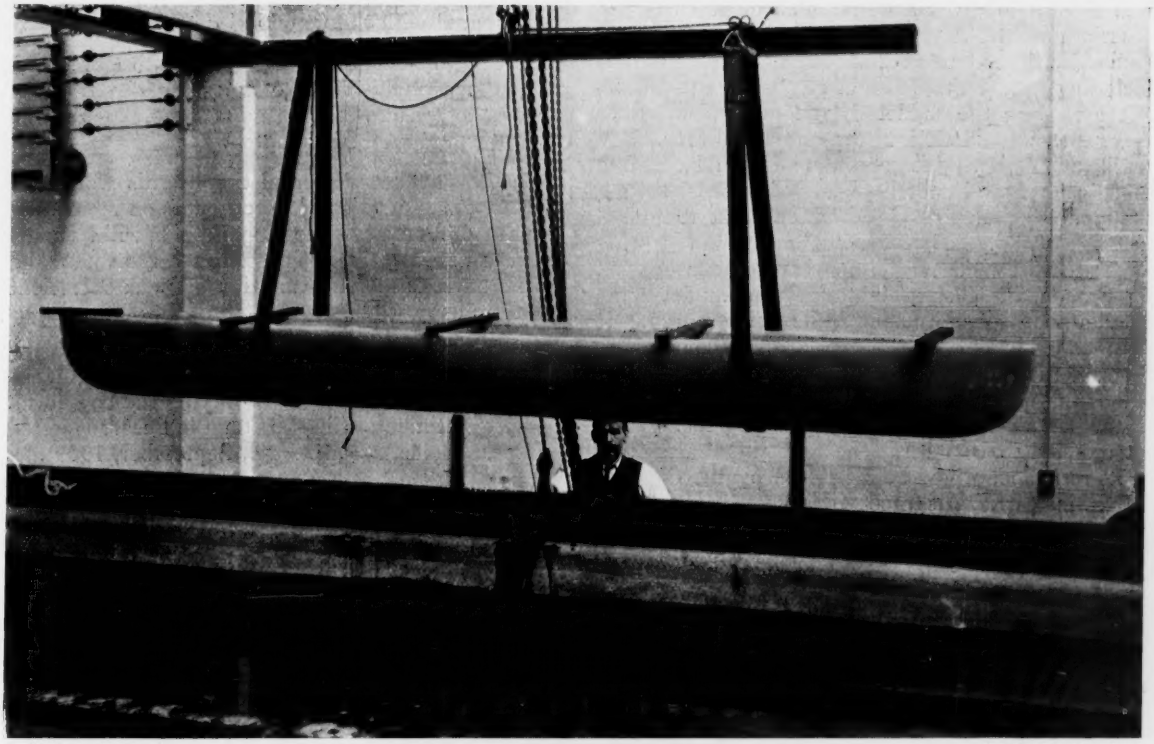

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FIGURE 5. A Wax Model of a Hull.

total resistance of the model has been found by towing experiments the wave- and eddy-making resistance, which is not mathematically ascertainable, can be found by subtracting the frictional resistance from the total resistance.

Newton's law of mechanical similarities, first applied by Froude in the calculation of the resistance of ships, and therefore called "Froude's Law," enunciates the theorem that if two geometrically similar ship bodies are moving at corresponding speeds through the water, the wave- and eddy-making resistances of these bodies are proportional to the third powers of their linear measurements or displacements.

As soon as the wave- and eddy-making resistance of the model has been found by experiments it need only be multiplied by a^3—the third power of the proportional displacement of ship and model—in order to obtain the corresponding resistance of the ship. If the frictional resistance of the ship is added to this resistance the total resistance of the the ship can be found by a simple mathematical formula.

It will be readily understood that in experiments of the nature indicated the most important instrument of precision is the towing carriage, the mechanism which registers the resistance to towing set up by the wax models. The carriage at Teddington spans the whole width of the tank and is borne on four wheels, thirty-six inches in diameter, which travel on rails built on the sides of the tank. It is made entirely of steel and the illustration (see Figure 1) gives a better idea of it than any description. Its dimensions are thirty-two feet six inches by thirty-four feet six inches and its weight including all motors and electrical equipment, but excluding the model dynamometer and other apparatus, amounts to fourteen-and-a-half tons. The carriage is driven by four motors and can be run at more than four hundred registered speeds, towing the models at rates varying from one foot to fifteen feet a second. The dynamometer and towing apparatus are made to follow the methods evolved by Froude, at Haslar, and allow the model some small amount of movement while being towed. It is not possible in the space at our disposal to describe the electrical measuring apparatus. It must suffice to say that this apparatus, (so sensitive that if the length or breadth of the wax model were altered by a thousandth part, the resultant alteration of its resistance would be registered by the dials on the towing carriage) is fitted with several drums. The records taken on the main drum consist of time, distance and resistance. The first of these is given by an electric clock, which makes and breaks contact every half second. The distance towed is measured by a trigger, fitted to the fore girder, striking against points twenty feet apart, fixed to the rail sleepers at the side of the tank. This trigger is caused to swing and so complete an electro-magnetic circuit. Records of the trim of the model can be taken, when required, on separate drums.

There are two tanks at Teddington. The Great Tank (see Figure 4) is of dimensions as follows:—

Length.....	549-ft. over all.
Breadth.....	30-ft. on water line.
Depth of water....	12-ft. 3-in. along the middle line.

In the tank walls an observation window has been fitted on either side, about mid-length of the tank. An arc lamp is to be fitted on one side of the tank to illuminate the water through the window, so as to enable a passing model to be observed *under* water, and any phenomena to be photographed.

A smaller tank (see Figure 2), sixty-four-and-a-half feet in length, and of five feet width, has been made for the purpose of investigations with running water. Experiments can be made in this tank under two sets of conditions—either in the still water and the model being towed; or with the model held on a dynamometer arm and the water made to flow past at any velocity. For the second of these purposes a rotary pump has been fitted at one end of the tank, and provision has been made for reducing eddies. This pump will give a velocity of about three miles an hour to the water, and the velocity can be regulated as desired. Special apparatus has been designed for casting the wax models—in lengths varying up to twenty-five feet—and for making them exactly to scale. The initial programme of experiments is as follows:—

A standard model will be made to the same lines as that used at the Haslar Experiment Works, and the results of the experiments with this model will be compared with those at Haslar.

Further experiments will be made with (say three) models of widely different types already tried at Haslar, to ensure the general accuracy of the apparatus and methods adopted.

On the satisfactory completion of this work, and with a view to a series of experiments on mercantile forms, a preliminary set of experiments will be made on some typical forms of passenger-cargo and cargo vessels having as wide a variation of block coëfficient and form as possible.

In conjunction with the foregoing, some experiments will be made to test the effect produced on the diverging system of waves by varying the bow form. These experiments will start on the lines suggested by Lord Rayleigh (*Phil. Mag.*, September, 1909).

As further work to be undertaken at an early date, the Committee have approved the suggestion to explore thoroughly the wake in the afterpart of several typical models. Experiments would be made to give the direction of flow, the pressure, and the velocity head in the streams.

It has also been agreed that it is desirable to repeat, and, if possible, extend, Mr. W. Froude's experiments on friction; it is hoped to make observations on planks up to at least one hundred feet in length.

XUM

ON THE PROPER MOTIONS OF THE FIXED STARS.

By W. DOBERCK, PH.D., F.R.A.S., M.R.I.A.

HALLEY found that some of the brightest fixed stars had changed their places since they had been observed by the ancient Greeks, and such changes are so obvious as to be recognised on ancient coins. Sir William Herschel, in 1783, arrived at the conclusion that a relative motion of the Sun among the fixed stars in the direction of a point situated near λ Herculis would account for the greater part of these proper motions: the motion of the sun towards the "apex" must cause the fixed stars in half the sky to apparently move away from that point, and in the other half of the sky to move towards the diametrically opposite point, the "anti-apex." Since then a great many astronomers have determined the situation of the "apex," but the results do not agree very well, especially as regards the declination. Bessel investigated the matter and declared himself dissatisfied with the evidence. When the direction of the proper motion of a fixed star has been ascertained, a great circle laid through the positions of the star observed at two epochs is thereby determined, and if the great circles belonging to different stars intersect in a point (the apex), it is easy to see that the poles of these great circles must lie on another great circle, of which the apex is the pole. Bessel found that the poles do not lie on or near a great circle but are scattered over the sky. Kobold, the editor of the *Astronomische Nachrichten*, who some years ago took up Bessel's investigations, proceeds as follows. He imagines the celestial sphere inscribed in a cube which touches the sphere at the two poles and at four points on the equator. He supposes the eye of the observer situated in the centre of the sphere, and any great circle on the sphere is then projected as a straight line on one or more of the faces of the cube. Kobold had already used maps made on this principle in determining radiants of shooting stars, and the writer had subsequently, in Hongkong, used similar maps for the same purpose. Kobold projected the poles of a great number of proper motions on such maps. Those that correspond to proper motions intersecting in the apex should lie on a straight line corresponding to the great circle of which the apex is the pole, but that is not clearly shown on the maps.

Kapteyn, who has the merit of having originated many hypotheses that appear destined to aid greatly in the astronomy of fixed stars, solves the difficulty by accounting for a great number of proper motions on the supposition that there are two distinct apices both close to the galaxy. It had, indeed, in course of years, become the general impression that the galaxy is made up not of isolated heavenly bodies but of a conglomerate of clusters of stars and nebulae. There was, therefore, nothing extraordinary in the circumstance that the stars belonging to two clusters did not move in the same direction. Kapteyn's hypothesis has been examined at the Greenwich Observatory and confirmed there by the independent evidence of proper motions, other than those used by Kapteyn. It has been confirmed also at the Cape of Good Hope. It has been to some extent confirmed by spectroscopic evidence at the Cape Observatory and at the Lick Observatory.

The speed in miles with which a star is moving towards or away from the earth can be measured in the spectrum, the wave-length of the lines being respectively shortened or lengthened, and it is found that the stars on opposite sides of the sky indicate a general drift or even two drifts, but the objects used should be evenly distributed over the whole sky, and the spectra of only few faint stars are known with sufficient accuracy for this purpose.

Meantime other radiants have been found. Boss, editor of the *Astronomical Journal*, has shown that the Hyades form a great cluster moving in parallel lines towards a certain radiant point. Another apparently (but perhaps only apparently) much larger cluster, which has been investigated at the Potsdam Observatory, contains the stars in the Great Bear, Sirius and other bright stars.

As mentioned above, the spectroscope enables astronomers to measure the motion of a heavenly body in the line of sight in miles per hour. The proper motion, expressed in seconds of arc, shows how much it is moving in the line perpendicular to the line of sight. When the direction of motion in space is known, then the parallax is at once obtained from these two quantities, and that direction is given by the radiant. Parallaxes of fixed stars are more accurately determined in this way than by any other method. Numerous results have been obtained. They show that the magnitude of a star forms no guide to its distance from us. Stars of different intrinsic brightness are mixed in space. Therefore, it would be no wonder if some of the small telescopic stars should turn out to be comparatively near the solar system. Proper motions have hitherto been determined by comparing positions recently determined by the meridian circle with older results. Burnham, at the Yerkes Observatory, has of late years determined a number of proper motions by aid of micrometric measures compared with previous measures made by Struve, Sir Robert Ball and others. In those cases where his results differ from the result of meridian work, the difference is probably caused by hitherto unsuspected proper motions of faint stars, which it will be possible to determine by future

XUM

micrometric measures compared with Burnham's observations. At Heidelberg proper motions of faint stars are discovered by simply looking in a stereoscope at photographic plates of the same part of the sky taken several years apart. Turner has discovered large proper motions of stars as faint as the eleventh magnitude marked on photographic plates, and states that stars with proper motions greater than 15″ per century are scattered with no sensible reference to the galaxy.

It may be asked what becomes of Herschel's explanation of the apex caused by the Sun's proper motion when there are not one but many apices. It should be kept in mind that all motion is relative, and it is quite legitimate to attribute the apex of the cluster that contains the largest number of stars to the proper motion of the Sun. Boss has lately discussed about six thousand proper motions, and he determines the apex without taking into account the existence of different systems, and also without excluding any objects.

It appears that all the radiants so far found lie near the galaxy, and it is much easier to determine additional radiants on the supposition that they all lie near the galaxy, than if they were scattered over the sky. If the pole of the galaxy is projected on Kobold's maps, and also the straight line (or rather lines) corresponding to the great circle of the galaxy, any straight line from the projected pole to any point on the projected galaxy represents a great circle perpendicular upon the galaxy, and the projected poles of proper motions that lie near this line indicate stars the radiant of whose proper motions is the pole of the galactic meridian in question. By investigating the proper motions all round the sky in this manner it should be easy to discover all the radiants that lie near the galaxy.

Kapteyn, on the supposition that there are only two radiants, explains these as being caused by stars moving in two diametrically opposite directions, and the fact that they do not appear to be diametrically opposite he explains by combining the proper motion of the Sun with each of them. In this way the direction of the Sun's proper motion is determined, but it is seen that the Sun belongs to neither of the clusters. However, there are probably more than two star streams, and there is so far no reason to suppose that they move in exactly opposite directions.

It is conceivable that two globular clusters might attract each other, approach, and pass through to the opposite side. When they had reached the same distance apart on the other side, they would stop and their motion would be reversed. The period of the swing of such a pendulum would exceed millions of years. But when the enormous distances between the stars are taken into account and their relatively insignificant sizes, the forces are found too insignificant to account for existing proper motions. The energy of runaway stars cannot be derived from attractions between fixed stars or clusters: it may be due to explosions.

As all observations of heavenly bodies are made by comparison with positions of fixed stars, the accurate determination of the proper motions of the latter may be said to be in some sense the most important object of astronomical observation. Several astronomers, especially Porter in Cincinnati, have devoted their energies to the discovery and determination of proper motions. An international coöperation between observatories in all parts of the world is being arranged to make a determination with the utmost accuracy of the positions of a very great number of fixed stars evenly distributed over the sky to serve as standards for determining the positions of faint stars recorded on photographic plates. But however perfectly the catalogue embodying the results of such coöperation may reflect the actual situation in the sky of the stars it contains, it must in a few years become quite inaccurate as the stars change their places, and for the determination of these changes the catalogue must rely on observations made in the past, so that the old observations, far from being superseded, gain in importance; and the older they are, the more important it becomes to take them into consideration.

CORRESPONDENCE.

THE FLIGHT OF BIRDS.

To the Editors of "KNOWLEDGE."

SIRS,—The representation by Gätke and others of the prodigious rapidity of the flight of migrating birds does not appear to rest on observations bringing conviction. I suggest that some knowledge on the subject might be obtained. An amazing number of birds are killed by dashing against the lighted lanterns of lighthouses. Therefore, I should suppose that, if on a "fly-line" near the shore there were placed a dark screen, twenty feet square, and in the middle thereof there were an aperture of, say, six feet diameter, covered with such material as that which equestrians jump through at a circus, and that it were very strongly lighted from the land side, immigrant birds travelling in the dark would make for it, and dash right through the flimsy material. They should then come in sight of another similar screen three hundred yards away, in the middle of which should be a disc of strong glass very brightly lighted from behind. At this the birds would dash as they do at the lantern of the lighthouse, and would fall dead—to be identified and registered by an attendant naturalist. The time of the first screen being broken by a bird and its death at the second should be taken by stop-watches. Between the screens a man should have a camera with which to cinematograph the approaching bird. There should be a contrivance for immediately replacing the broken flimsy in the first screen.

The birds on reaching the coast might, perhaps, have slowed down through fatigue, but the bright lights might stimulate them to renewed exertion.

Years ago, crossing the Channel from France, I observed a small bird accompanying the steamer for a mile or so. I could not say *pari passu*, for it frequently spurted, going with apparent ease ahead of us and then dropping behind. The speed of that bird during that flight, till it disappeared, could hardly have exceeded ten miles an hour.

Some migrants fly high: but the light of a bright screen might bring some of them down to its level. FRANCIS RAM.

HINTS ON THE PREPARATION OF SKELETONS OF VERTEBRATES.

By J. A. BULLBROOK.

FOR the serious study of Comparative Anatomy there is nothing better than the preparation of typical skeletons of the classes and orders of Vertebrates. It is axiomatic that Morphology cannot be learned from text-books alone.

Moreover, though museum preparations are useful complements to practical study, they cannot supersede it. Much can, and must, be learned from the museum, because the material cannot be observed elsewhere; but such study is only superstructure, the foundation must be laid in the laboratory or home.

The fascination of preparing and mounting skeletons of various animals, for study or exhibition, does not seem to be appreciated by either the student or the amateur naturalist.

Yet, of all practical methods of obtaining correct and precise information concerning animal structures, this is certainly the best and probably the most interesting—that is if it is carried out intelligently.

It *is* possible to prepare a skeleton and yet have learned very little, or nothing at all, about the real nature of the animal or its anatomy.

The work should be done systematically and in definite order, and never without the aid of good diagrams, or, failing these, a lucid and exact description. To be of any value, the skeleton must be prepared for use and constant examination, not merely as a specimen of neat and clever handicraft.

Although this article is intended primarily for students, I hope to make it appeal also to the amateur naturalist, who has, perhaps, but little time and limited means to bestow upon his hobbies.

Now, just in these two particulars, this work is valuable. It is true that the preparation of a skeleton takes a great deal of time; but on the other hand, the work may be done at odd moments. In point of fact one is almost sure to spoil a specimen by working at it too long at a time; the work requires patience and plenty of it, and will not be hurried. A long sitting, therefore, is not only unnecessary but really disadvantageous. As to expense, all the necessary instruments and reagents may be purchased for a few shillings, and the material, with few exceptions, may be collected by the enterprising worker at the cost of a little energy and toil. Indeed, this is one of the charms of the work, that it entails a study of natural history in almost every aspect. It is far better to go into the country and gather the material first hand, so learning something of the habits and the haunts of animals, than to rely on the live-stock dealer. For the convenience of the reader, I have appended to this article a list of the necessary apparatus and reagents, with their approximate cost, and a list of animals which are easily obtained and are of most value for dissection.

Before, however, one can hope to make a satisfactory preparation, one must spoil some material and make several practice attempts, both at preparing and mounting. For these practice attempts, many advocate using frogs. I, myself, prefer the toad. It is almost as easy to obtain and it has the advantage that the bones are larger. I have illustrated this article with the photographs of some skeletons, including that of the toad *(Bufo vulgaris)*. I will describe first the preparation and mounting of the latter skeleton, and this will apply to all vertebrate animals (except fishes) up to the size of a mole or rat. Larger animals should be mounted articulate or, better still, put into boxes partitioned for the different skeletal regions. They can be mounted on black boards by using wire, but there is no advantage, and the specimen then takes up a great deal of space. As to the preparation of fishes' skeletons, they are unsuitable to any but the advanced student, and will not be described in this paper.

Now, there are two things, one or both of which the beginner is always tempted to do; either to bury or to boil the animal, hoping to pick out the bones clean and just ready to dry and mount. I never knew of a really good specimen being procured by either of these methods. Moreover, by doing either, nothing whatever is learned of the soft parts, and all the meaning of the marks on the bones and their varying shapes is lost.

The animal should always be dissected first and then macerated.

A good description and diagrams are essential. There are in most places libraries which contain some books on Comparative Anatomy. It is not absolutely necessary to have a picture or description of the animal or its skeleton as a whole, though it saves trouble, and few text books have such descriptions of many animals. It is best, therefore, to

fall back on such books as "Mivart's Lessons in Elementary Anatomy," which contain good diagrams and lucid descriptions of the various regions—if not actually of every animal, at least of so many types that almost any skeleton may be prepared from them. I have appended a list of books which will be of use and easily obtained.

To start with the dissection. This is an art which cannot be taught; it can only be learned by patient and plodding labour. The toad should be dissected carefully and thoroughly, with the aid of a book. All the structures and organs should be noted, and drawings made at the different stages of the dissection, especially of the muscles and ligaments. When satisfied that the soft parts have been properly studied, as much of the flesh as possible is cut from the bones, and the ligaments are carefully examined.

The body must now be macerated. This process consists of soaking the body in water for an indefinite period. For this purpose zinc tanks are useful (never iron or tin), of the following dimensions:—4-in. long, 3-in. wide, 1½-in. deep, for small animals; and 6-in. long, 4-in. wide, and 2½-in. deep for larger animals; these should always have tight-fitting lids. A useful substitute, however, is a pie dish or other shallow earthenware vessel, covered with a sheet of glass. It is often advisable to macerate the body in sections, taking care always to keep together the bones of similar regions. Especially is this method useful with larger animals, as in this case the quantity of flesh one is obliged to leave on the bones after dissection is often considerable, and by putting them into separate tanks one obtains a larger mass of water to each bone, and so expedites the process of rotting. The hands and feet should *always* be cut off at the joints, and each macerated separately in a small earthenware or glass jar. While it is macerating, the specimen needs frequent attention. The vessel should always be kept covered when one is not actually working on it, and the specimen must never be allowed to dry up.

As soon as the bone is loose and all flesh on it is soft, it is taken out and put aside in fresh water or preservative (weak spirit or formaldehyde solution) after it has been carefully cleaned. I do not advocate retaining the ligaments. These should be studied in the fresh condition, unless the object of the preparation be essentially to display them. Should one wish to keep them, the macerating specimen will need careful watching, and it must be taken out of the tank immediately when any ligaments show signs of coming away from the bones. Should any flesh still be adherent, it should be scraped off gently with a scalpel. But for the preparation in question, viz.: the toad, the ligaments are not required. When macerating do not remove too much of the débris at first, as by so doing the bacterial action is liable to be retarded. After decomposition has thoroughly commenced it is advisable to take out some of the rubbish from time to time. For this purpose an old table fork is very useful.

As one takes out the bones they must be cleaned. This is a very tiresome and delicate process. Except for large bones the knife should not be used. A camel-hair brush, an oil-painter's flat bristle brush with the bristles cut down to about a quarter of an inch; a couple of needles mounted in handles; a pair of fine forceps; and a pair of fine-pointed scissors, curved on the flat, are the necessary instruments. Any stubborn fibres of ligament should be cut off close with the point of the scissors; the flesh and débris are brushed off with the hard brush, and the bone is finished by brushing with the soft brush. The brush should always be used in one direction only, not to and fro. The bones should always be held in the forceps—never in the fingers, and the whole cleaning should be done as far as possible under water. A piece of ground glass, made to fit the bottom of the cleaning vessel and with its smooth surface blackened with paint, so that the colour shows dull through the ground surface, is very useful as the bones show up clearly upon it when one is cleaning them. If after cleaning, some pieces of flesh still adhere tightly to the bones, they must be macerated further.

It sometimes happens that the ligaments will not yield to maceration; especially is this the case with the hands and feet of all vertebrates and the vertebrae of Ophidia. In this case boiling becomes necessary. The bones should be boiled in a small enamelled saucepan, the smaller the better. Before putting them into the saucepan, a few drops of strong solution of caustic potash may be added to the water; very little should be used and the potash should never be added in solid form, because it takes some time for it to diffuse and the specimen is liable to injury through coming in contact with a very strong solution. The liquid potash should be added to the water, drop by drop, and the whole well stirred before putting in the bones.

The ligaments will often soften by just bringing them to the boil, and the specimen must never be boiled for more than a quarter of an hour. It is not advisable to boil the bones clean; they should be cleaned, in the manner mentioned above, after boiling.

The next process after cleaning is bleaching. When all the bones are clean they should be washed free from any preservative—if such has been used—with distilled water. They are then placed in a glass vessel in a 1 in 20 solution of hydrogen peroxide. The strength is made by mixing the strong solution ordinarily sold, with 19 parts water. This does not of course represent 1 part H_2O_2 in 20 of water. The vessel containing the bleaching bones should always be kept covered with a sheet of glass so that no oxygen is lost. Never use chloride of lime for bleaching as it injures the bones and destroys the markings.

The vessel should be broad and shallow so as to obtain the greater surface area, and it should be placed on a white surface so that the light is reflected

fairly equally on to all parts of the bones. The bones are whitened more quickly by adding a few drops

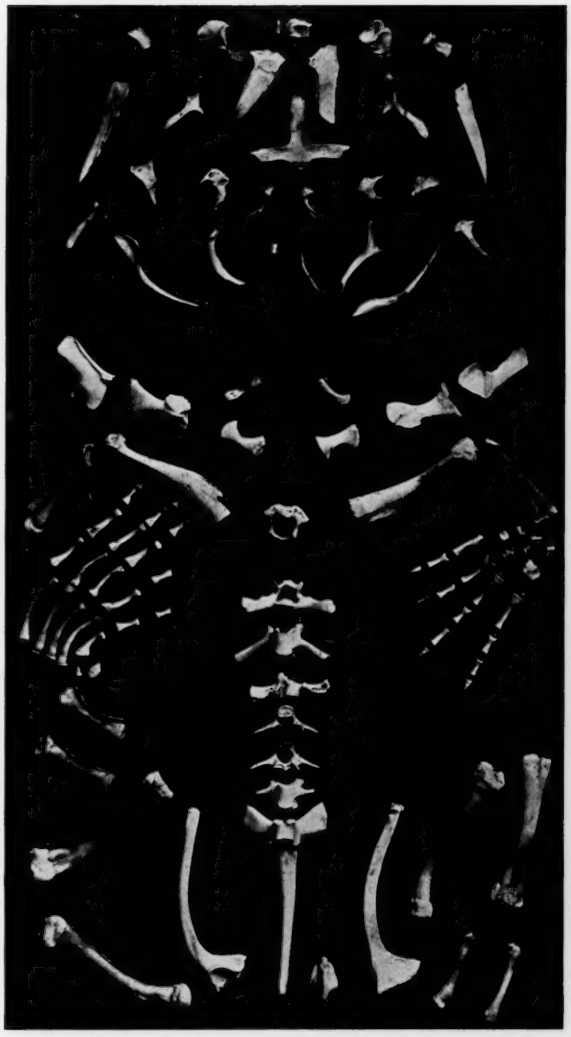


FIGURE 1. A Skeleton of a Toad *(Bufo vulgaris)*.

of caustic potash to the peroxide solution, but this should only be done with the larger bones, as the small ones absorb a good deal of the caustic and rapidly turn yellow after mounting. In any case very little potash must be used or else tubercles and other markings will be obliterated. Hydrogen peroxide is harmless, but caustic potash is not. The bones should all be placed in the same strength of bleaching solution and remain in it for the same length of time, *i.e.*, until all are whitened. But it is advisable still, and indeed throughout, to keep the hands and feet separate from the rest, each being prepared in a separate dish.

After bleaching, the bones should be washed carefully again in distilled water; any débris still adherent may be taken off with a soft brush and the bones thoroughly dried. For this purpose a few racks are required. For larger bones these are best made of what is known as expanded metal, *i.e.*, iron sheet stamped through with slits and then drawn out into diamond-shaped net-work. Squares of this material are nailed on at the sides to wooden blocks, this form of rack allowing the air to circulate freely all round the bone. The iron should be covered with some hard enamel to prevent the bones being injured by rust. For small bones, a porous earthenware plate such as is used by chemists for drying crystals, is best, although blotting paper will serve the purpose. The bones should be picked out one by one—not shot out promiscuously—and left to dry for at least twenty-four hours. Should any débris resembling bones remain in the solution, a slight pinch with the forceps will always indicate their true character.

There now only remains the mounting. This

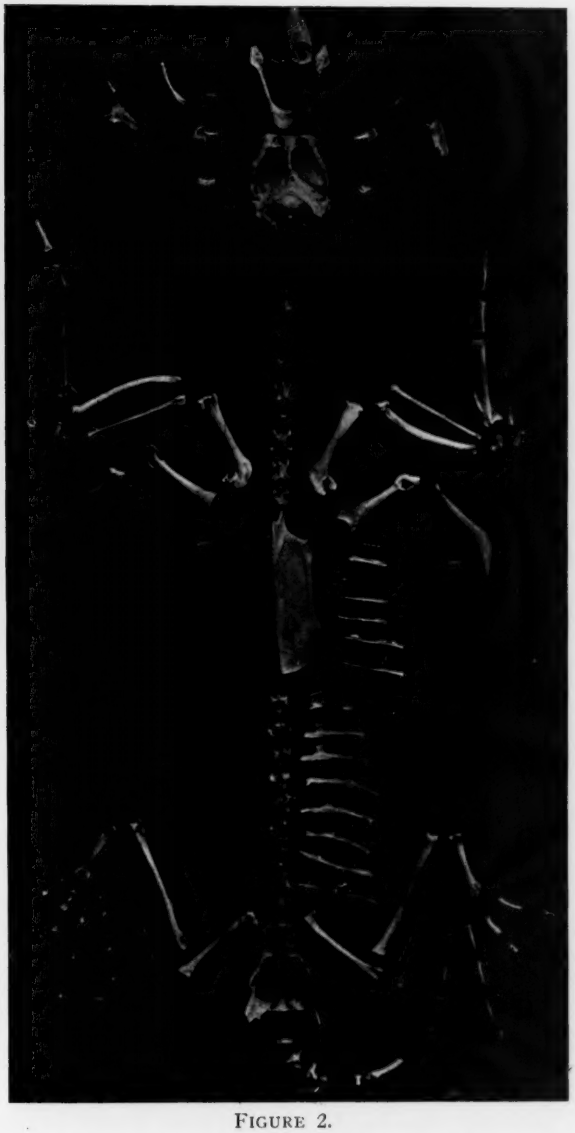


FIGURE 2.
A Skeleton of a Love Bird *(Androglossina agapornis)*.

should be done as far as possible at one sitting. The bones should be taken and arranged on a card, or, better still, on the blackened glass sheet, in their respective natural positions, the different regions being spaced distinctly. The skeleton should be mounted in a similar fashion on stiff card which has first been carefully blackened with a dull pigment (such as ivory black) as seen in the illustrations, and thoroughly dried. A good method is to paint red lines around or between the different regions. I would advocate mounting all one's skeletons on the same plan, and I think that the best is that shown in the accompanying figures (1 and 2). It is mapped out thus:—

Lower Jaw and Hyoideal Face and Cranium.

Hand. Fore limb. Pectoral Girdle. Fore limb. Hand.

Cervical to Sacral Vertebrae

Caudal Vertebrae

Foot. Hind limb. Hip Girdle. Hind limb. Foot.

The bones on either side are to be placed showing inferior and superior surfaces respectively, so as to display the various markings, and so on. The mounting is done with a fine camel-hair brush dipped in benzol solution of Canada balsam. This should not be too stiff or a skin will form before the bone can set; nor must it be too thin, or it will soak into the bone and discolour it. In mounting the bone, it is held in position above the card by the forceps, and the brush is drawn over the card so that it leaves a film of balsam as near the shape and dimensions of the bone as possible, on which the latter is then dropped. Only sufficient balsam should be used to ensure the bone remaining on the card, and care should be taken not to soil the forceps with the mucilage, or the marks of the bones may be masked. The specimen is now placed in a box into which the card fits exactly, and is kept in a horizontal position. The preparation is now complete save for the drying of the balsam, which takes a week or two.

Regarding the preparation of skeletons of larger animals, little need be added to what has already been said. The bodies may, however, be boiled with less risk, and both in cleaning and bleaching, caustic potash may be used at discretion. A tooth brush and nail brush are necessary for cleaning, and the knife may be used more freely.

The mounting, however, of larger preparations differs considerably from that already described.

The bones, except the vertebrae, hands and feet, should be left loose. Those of the hands and feet should be mounted on black cards, unless they are large, when they should be bored and strung on catgut in their proper positions. The best instrument for boring is a "fiddle drill" such as is used by jewellers. The skeleton should be kept in a box and divided up into regions as before, each region being placed in a separate partition for easy reference.

For larger animals, it is useful to keep two skulls, one articulate and one disarticulated. To disarticulate the skull, it is first cleaned, and all the brain matter removed with a scoop. The cranium is then filled through the Foramen Magnum with raw rice or dried peas, according to the size of the foramina in the skull, and the Foramen Magnum plugged tightly with a cork. The whole is then placed in cold water in a saucepan and boiled until the grain, by swelling, has forced the bones apart at the sutures. The bones are then taken out, washed and bleached.

It is sometimes useful to keep cartilaginous structures. To retain these in their original shape is difficult, in fact, almost impossible. The most satisfactory method of preparing them is to dissect them; clean; place in good methylated spirit for twelve hours; soak in moderately thick solution of Canada balsam for at least three days; and then allow them to dry hard.

I have purposely refrained from any description of the methods of articulating skeletons. This work would require an article to itself, and is unsuitable to the beginner.

LIST OF ANIMALS SUITABLE FOR SKELETONS.

Rana temporaria (frog)	Batrachian.
Bufo vulgaris (toad)	do.
Triton cristatus (crested newt) ...	Tailed Batrachian.
Lacerta vivipara (grass lizard) ...	Lacertilia.
Tropidonotus natrix (common snake)	Ophidia.
Sturnus vulgaris (starling) ...	Aves.
Mus decumanus (rat)	Rodentia.
Talpa europea (mole)	Insectivora.
Erinaceus europeus (hedgehog) ...	do.
Canis familiaris (dog)	Carnivora.
Felis domesticus (cat)	do.
Sciurus vulgaris (squirrel) ...	Frugivora.
Cercopithecus callitrichus (green monkey)	Anthropoid monkeys.

LIST OF BOOKS.

Lessons in Elementary Anatomy ...	St. George Mivart, M.D.
Osteology of Mammalia	W. H. Flower, F.R.S.
Comparative Anatomy	Weidersheim.
Practical Zoölogy	T. J. and W. N. Parker.
Manual of Zoölogy	H. A. Nicholson.
Text-book of Zoölogy	T. J. Parker & W. Haswell
The Cambridge Natural History ...	

LIST OF NECESSARY APPARATUS, INSTRUMENTS AND REAGENTS.

Fiddle drill and drills	3s. 6d.
Dissecting forceps	1s. 6d.
Fine forceps	1s. 6d.
Double-spooned brain scoop	1s. 6d.
Two needles in handles	3d. each.
Dissecting scissors	1s.
Fine-pointed scissors curved on the flat ...	1s. 6d.
Two scalpels	1s. 6d. each.
Glass jars	1d. each.
Porcelain developing dish (¼-plate) ...	1s.
Glass covers...	1d. and 2d. each.
Glass dishes with covers	6d. to 2s. each.
Drying racks	2d. each.
do. plate...	1s.
Watch glasses	1d. each.
Blackened glass	4d.
Zinc tanks	9d. to 2s. each.
Hydrogen peroxide (20 Vols.)	2d. per oz.
Potassium hydroxide (sticks)	1s. per lb.
Methylated spirit	4d. per pint.
Carbolic acid (crystals)	2d. per oz.
Formaldehyde solution (40 %)	4d. per oz.
Canada balsam (in benzol)	4d. per oz.

SOLAR DISTURBANCES DURING MARCH, 1911.

By FRANK C. DENNETT.

THERE was a slight increase of activity upon the Sun's surface during March, and the repetition of outbreaks upon, or close to, the site of previous disturbances was very marked. The disc appeared free from disturbance on March 6th, 15th, and 17th, and only faculae were observed on 13th, 14th, 18th, 19th, 20th, 21st, 22nd, 26th, and 27th. The longitude of the central meridian at noon on March 1st, was 237° 34′.

No. 5 remaining visible until March 5th is shown on the chart.

No. 6.—A group of pores, a leader with some tiny companions in front, with a larger pore bringing up the rear. The group was 39,000 miles in length, and remained visible from the 2nd until the 5th, and on the 7th two black pores were seen close to the same place.

No. 7.—A pore amid faculic surroundings only seen on March 5th.

No. 8.—A small spot came round the eastern limb, and continued visible from the 8th until the 12th.

No. 9.—A pair of pores about 37,000 miles apart, in a very bright faculic disturbance, marking the site of No. 6, seen on the 10th and 11th of March.

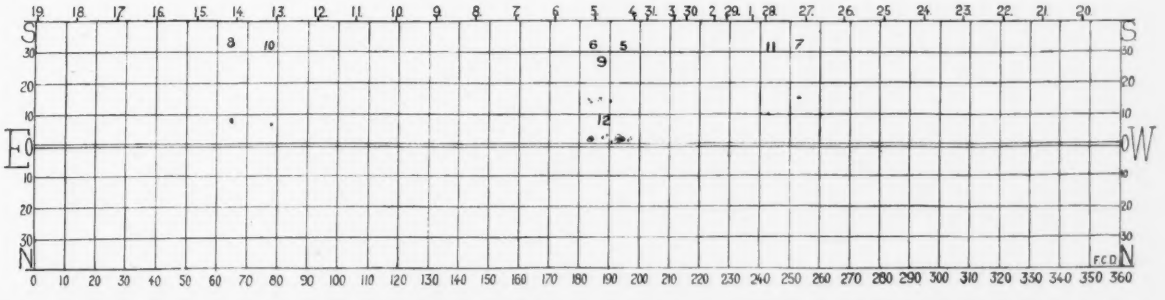
No. 10.—A solitary pore seen only on the 16th.

No. 11.—Another single pore with faculae around it, seen only on March 24th and 25th.

No. 12.—After the disappearance of No. 5. The site was marked by a fine faculic disturbance as it approached the limb on the 9th and 10th. It was found on the 26th to have come round the eastern limb, and on the 28th a group of four black pores had made their appearance in the group. On the 31st there was a considerable spot as leader, and another as trailer, with some pores between them. On April 1st, the leader was preceded by a tiny pore, and the whole of the group following the leader was made up of pores, the rear ones partially outlining an ellipse. On the 4th there was seen to be a black hydrogen flocculus close to a pore, east of the leader, and the pore seemed to increase in size. When just within the limb on the 6th, the leader, which alone remained visible, appeared to be increasing in size. The leading spot attained a diameter of 15,000 miles, and the group a length of 83,000 miles.

The chart is constructed from the combined observations of Messrs. J. McHarg, A. A. Buss, E. E. Peacock and the writer.

DAY OF MARCH.



THE FACE OF THE SKY FOR MAY.

By W. SHACKLETON, A.R.C.S., F.R.A.S.

THE SUN.—On the 1st, the Sun rises at 4.35 and sets at 7.19; on the 31st he rises at 3.51 and sets at 8.3. Sun-spots and faculae may usually be seen on the solar disc, but spots are small and not numerous. The positions of the Sun's axis, equator, and heliographic longitude of the centre of the disc are shown in the following table:—

Date.	Axis inclined from N. point.	Centre of Disc S. of Sun's Equator.	Heliographic Longitude of Centre of Disc.
May 1	24° 22′W	4° 6′	152° 46′
,, 6 ...	23° 24′W	3° 35′	86° 41′
,, 11 ..	22° 16′W	3° 2′	20° 34′
,, 16 ...	20° 58′W	2° 29′	314° 26′
,, 21 ...	19° 29′W	1° 54′	248° 18′
,, 26 ...	17° 52′W	1° 19′	182° 9′
,, 31 ...	16° 5′W	0° 43′	115° 59′
June 5 ...	14° 11′W	0° 6′	49° 49′

THE MOON:—

Date.	Phases.	H. M.
May 5 ...	☽ First Quarter	1 14 p.m.
,, 13 ...	○ Full Moon	6 10 a.m.
,, 21 ...	☾ Last Quarter	9 23 a.m.
,, 28 ...	● New Moon	6 24 a.m.
June 3 ...	☽ First Quarter	10 4 p.m.
May 15 ...	Apogee	6 48 p.m.
,, 28 ...	Perigee	5 24 p.m.
June 11 ...	Apogee	10 42 p.m.

There is a Penumbral Eclipse of the Moon on the morning of the 13th, but since the Moon sets before the middle of the eclipse and only passes through the penumbra very little can be seen. The following are the particulars:—

	May 13th.
First contact with the Penumbra	$3^h\ 46^m$ a.m.
Middle of the eclipse	$5^h\ 57^m$ a.m.
Last contact with the Penumbra	$8^h\ 7^m$ a.m.

The first contact occurs at 65° from the North point of the Moon's limb towards the East. The Moon sets at Greenwich at $4^h \cdot 7^m$ a.m.

OCCULTATIONS.—No naked eye stars are occulted and visible from this country during the month.

THE PLANETS.

MERCURY:—

Date.	Right Ascension.	Declination.
	h. m.	
May 1 ..	2 55	N 18° 11′
,, 11 ...	2 35	13° 48′
,, 21 ...	2 31	11° 26′
June 1 ...	2 57	13° 6′
,, 11 ...	3 44	N 17° 11′

On May 5th, Mercury is in inferior conjunction with the Sun and therefore unobservable. Towards the end of the month the planet is a morning star in Aries rising at 3.11 a.m. on the 31st. On June 1st the planet is at greatest westerly elongation from the Sun of 24° 30′. The planet is in conjunction with Saturn on the 29th May, at 3 a.m.

VENUS:—

Date.	Right Ascension.	Declination.
	h. m.	
May 1 ...	5 0	N 24° 25′
,, 11 ...	5 51	25° 29′
,, 21 ...	6 42	25° 21′
June 1 ...	7 36	24° 0′
,, 11 ...	8 23	N 21° 42′

Venus is a brilliant object in the evening sky, looking N.W. by W. immediately after sunset.

The planet is well placed for observation, appearing high above the horizon at sunset, and not setting till 11.15 p.m. on May 14th, and 11.22 on May 31st.

As the distance from the Earth diminishes, the apparent diameter of the planet increases, and is now about 16″; later in the year, when the planet appears still brighter, the diameter increases to over 40″

The planet can readily be seen with the naked eye long before it is dark, and a telescope of only 1-inch aperture is sufficient optical aid to find it in broad daylight when directed to the correct position in the sky.

As seen in the telescope, the planet appears gibbous, 0·7 of the disc being illuminated; broad daylight is the best time for observing, and with magnifying powers of 150 to 250 on 4-inch or 5-inch telescopes shadings may be seen on the planet's disc on the terminator side, the limb appearing intensely brilliant. The Moon appears near the planet on May 1st, and on the 30th, conjunction takes place with Neptune.

MARS:—

Date.	Right Ascension.	Declination.
	h. m.	
May 1 ...	22 34	S 10° 45′
,, 11 ...	23 2	8° 3′
,, 21 ...	23 29	5° 16′
June 1 ...	23 59	S 2° 10′
,, 11 ...	0 26	N 0° 38′

Mars is a morning star, rising E. by S., about 2.20 a.m., near the middle of the month. The apparent diameter of the planet is only 6″·5. This is too small for useful observations to be made; towards the end of the year, however, the planet is in opposition, and the apparent diameter will then be three times the above amount.

JUPITER:—

Date.	Right Ascension.	Declination.
	h. m.	
May 1 ...	14 31	S 13° 23′
,, 11 ...	14 26	13° 0′
,, 21 ...	14 21	12° 39′
June 1 ..	14 17	12° 19′
,, 11 ...	14 14	S 12° 7′

Jupiter is in opposition to the Sun on May 1st, and hence at this time he appears on the meridian at midnight, and, moreover, he then appears at his brightest.

XUM

The planet is a very conspicuous object in the evening, looking S.E., rather low down; on May 1st he rises at 7.2 p.m., and throughout the month he has risen in the E.S.E. before the Sun has set.

The planet is describing a retrograde path near the star λ Virginus.

On account of the belt markings on the disc, and his bright satellites, this is the easiest and most interesting planet to observe in small telescopes. The polar flattening is also a noticeable feature, since the equatorial diameter is 44″ and the polar diameter 2″·8 smaller.

The Great Red Spot has been difficult to observe during the past few years, but the period deduced from observations of the spot give the planet's rotation as $9^h\ 55^m\ 38^s$.

The rapidly moving satellites present a diversity of configurations in the same evening; the following table gives their principal phenomena observable before midnight.

Date.	Satellite.	Phenomenon.	P.M.'s. H. M.	Date.	Satellite.	Phenomenon.	P.M.'s. H. M.	Date.	Satellite.	Phenomenon.	P.M.'s. H. M.
May				May				May			
1	I.	Oc. D.	8 55	16	I.	Tr. I.	9 35	24	III.	Sh. I.	10 7
1	II.	Ec. R.	9 14	16	I.	Sh. I.	9 57	24	II.	Tr. E.	10 38
1	I.	Oc. R.	11 5	16	I.	Tr. E.	11 46	24	I.	Ec. R.	11 15
2	I.	Sh. E.	8 20	17	II.	Sh. E.	9 10	24	II.	Sh. E.	11 44
8	II.	Oc. D.	8 55	17	I.	Ec. R.	9 21	24	III.	Sh. E.	11 45
8	I.	Oc. D.	10 38	23	I.	Tr. I.	11 20	31	I.	Oc. D.	10 18
8	II.	Ec. R.	11 51	23	I.	Sh. I.	11 51	31	II.	Tr. I.	10 20
9	I.	Tr. E.	10 1	24	II.	Sh. I.	9 8	31	III.	Tr. I.	11 26
9	I.	Sh. E.	10 14	24	III.	Tr. E.	9 21	31	II.	Sh. I.	11 42
15	II.	Oc. D.	11 11								

"Oc. D." denotes the disappearance of the Satellite behind the disc, and "Oc. R." its reappearance; "Tr. I." the ingress of a transit across the disc, and "Tr. E." its egress; "Sh. I." the ingress of a transit of the shadow across the disc, and "Sh. E." its egress; "Ec. D." denotes disappearance of Satellite by Eclipse, and "Ec. R." its reappearance.

SATURN:—

Date.	Right Ascension.	Declination.
	h. m.	
May 1 ...	2 32	N 12° 43′
,, 17 ...	2 40	13° 21′
June 2 ...	2 48	N 13° 55′

Saturn is in conjunction with the Sun on May 1st, and therefore unobservable during the early part of the month. Towards the end of the month the planet is a morning star, rising in the E.N.E. at 3.34 a.m., on May 21st.

URANUS:—

Date.	Right Ascension.	Declination.
	h. m. s.	
May 1 ...	20 6 29	S 20° 49′ 7″
June 1 ...	20 5 14	S 20° 53′ 49″

Uranus rises about midnight on the 20th May, and about 11.18 p.m. on June 1st. The planet is unfavourably placed for observation as he is low down in the sky: he is describing a retrograde path in Capricornus about 2° S.E. of σ Capricorni.

NEPTUNE:—

Date.	Right Ascension.	Declination.
	h. m. s.	
May 1 ...	7 22 5	N 21° 30′ 19″
June 1 ...	7 25 15	N 21° 24′ 49″

Neptune is observable in the N.W. portion of the evening sky, not far from Venus, and is in conjunction with that planet on the 30th. The planet sets at 11.50 p.m. on the 15th.

The planet is difficult to identify among the numerous small stars appearing in the same field of view, as it requires a high power (about 300) and good definition to distinguish his disc; he can, however, be detected by his relative motion if observation be made on successive nights.

METEOR SHOWERS:—

The principal shower during May is the *Aquarids*. This may be looked for between May 1 to 6; the radiant being in R.A. $22^h\ 32^m$ Dec. S. 2°, near the star η Aquarii.

TELESCOPIC OBJECTS:—

DOUBLE STARS.—α Librae, XIV.^{h} 46^m, S. 15° 40′, mags. 3, 6; separation 230″; very wide pair.

σ Coronae, XVI.^{h} 11^m, N. 34° 8′, mags. 6, 6½; separation 5″·0; binary.

α Herculis, XVII.^{h} 10^m, N. 14° 30′, mags. 2½, 6; separation 4″·8. Very pretty double, with good contrast of colours, the brighter component being orange, the other blue.

δ Herculis, XVII.^{h} 11^m, N. 24° 57′, mags. 3, 8; separation 14″.

CLUSTERS.—M13 (cluster in Hercules) is situated about one-third the distance from η to ζ Herculis, and is just visible to the naked eye. It is a globular cluster, and with a three or four inch telescope the outlying parts of the cluster can be resolved into a conglomeration of stars.

QUERIES AND ANSWERS.

Readers are invited to send in Questions and to answer the Queries which are printed on here.

QUESTIONS.

35. MOVEMENT OF A TAUT WIRE.—When a taut wire, say a mile long, has a weight at one end and one pulls it a foot towards one at the other, does the distal end of the wire move at the same time as the proximal in one's hand, or is its movement later?

FRANCIS RAM.

36. METEORS.—It is stated in most books on Astronomy that meteors are ignited by friction with our atmosphere at a height of seventy miles sometimes. As the density at this height does not amount to nearly the millionth of that at sea level, can any of your readers explain how falling bodies could be ignited by such a rarefied atmosphere, even assuming that they move at the rate of forty-five miles a second, the maximum speed for meteors?

"PUZZLED."

37. ROTATION OF STUFFED BIRDS ATTACHED TO WIRES.—The little birds, which are suspended by wires in a case in the hall of the Natural History Museum, may be observed very slowly to rotate, the tips of their wings describing a quadrant of a circle, or more: and so they have done, I can aver, for the last twenty years. What is the cause of the movement?

FRANCIS RAM.

XUM

38. THE EFFECT OF GREAT ALTITUDES ON THEARS.—Is it true that persons ascending mountains experience. on reaching great altitudes, bleeding of the ears?

If so, would not this bleeding be beneficial to persons suffering from any congestion of the ears?

Thirdly, could an atmospheric condition similar to that which obtains at great altitudes be produced on the sea-level by any scientific process?

E.B.

39. ANTI-CYCLONE.—I should be much obliged by your favouring me with an explanation of the term "Anti-Cyclone." I have always understood it meant the opposite of Cyclone, viz., a perfect calm. This I have had disputed, and that the storms we have lately had from the Easterly have been caused by an "Anti-Cyclone." Now, if Anti-Cyclone and Cyclone both mean storms, why the prefix "Anti"? Some of the books I have, merely give "Cyclone," but do not mention "Anti-Cyclone," or if the term is referred to, it is only in a very vague way, and the language is by no means plain or explanatory.

WM. S. JEFFERY.

40. WATER-FINDING.—The other day, Mr. Pogson, a well-known water-diviner of Madras, located as many as six subterranean springs in a garden in Cuddalore, India. Wells were sunk at all the six spots, and, strangely enough, water was found in all of them at very nearly the same depth, and in approximately the quantity calculated by the diviner.

Like all other water-finders, Mr. Pogson locates water by means of an ordinary rod—either of wood or of metal—which, without any volitional effort on his part, spontaneously rotates in his hand when he stands above a bed of water underground, or points vertically downward if he happens to be over a spring of small dimensions. I should be very much obliged if a scientific explanation can be given of this wonderful phenomenon.

It may be well here to point out that Mr. Pogson is also endowed with magnetic susceptibility, by which he can tell which pole of a bar magnet is turned to him. Halley's comet, he says, affected him before and after its perihelion passage, exactly like the North and South poles of a magnet.

T. K. JOSEPH.

REPLIES.

10. WATER AND ITS OWN LEVEL.—The real meaning of the common expression that water finds its own level is identical with that of Mr. Yerward James ("KNOWLEDGE," March, 1911, page 103) that it seeks its "Appropriate Spherical Curvature." What he says about the variation in the surface of a cup of tea when lifted may be true, but there are so many influences in operation that it might take a little time for the fluid to adjust itself, the motion of lifting having some action besides the effects due to inertia, capillarity and friction. So the centre of gravity of the earth is affected by any displacement of particles on the surface of the earth, such, for instance, as when a boy throws a stone, or when a crane lifts a mass of rock, or when a ship takes a cargo of coal from one place to another.

As regards experimental proof of the convexity of the surface of water, reference should be made to the experiment tried on the Bedford Level Canal, a straight piece of water six miles long. This experiment was fully reported in *The Field* newspaper, March and April, 1870, and might be considered proof conclusive of the convexity of the surface of water.

LUMEN MARTIANUM.

30. FINDING THE TIME BY DAY.—(1) Local apparent time can be roughly found when the ratio of the length of an upright stick to the length of its shadow is known, by using the following method:—

Taking the data given by "Interested," and the angles to the nearest degree of arc, we have latitude=52° and Sun's declination on the given day=15° North. Call the length of the stick unity: then in the right-angled triangle whose perpendicular and base is the length of the stick and shadow respectively, we must find the angle ABC. In the given case (shadow twice the length of the stick) $\tan^{-1}\frac{1}{2}=27°=$angle CAB which is the altitude of the Sun above the horizon at the time the measurements are taken. It will now be necessary to find the northmost angle of a spherical triangle on the celestial sphere, three sides of it being given, viz. (90°−Sun's altitude) or Sun's zenith distance, the Sun's angular distance from the north pole of the heavens, and the colatitude of the place. Using the formula

$$\sin\frac{P}{2}=\sqrt{\frac{\cos s.\ \sin(s-a)}{\cos l.\ \sin p.}}$$

where P is the angle required (being the Sun's angular distance from the meridian and therefore equal to the time), a the altitude of the Sun, l the latitude of the place, p the Sun's polar distance, and s half the sum of the three last mentioned quantities, the times deduced are either $7^h\ 44^m$ a.m. or $4^h\ 16^m$ p.m., the shadow in this particular case having the same length twice during the day. This process, by the way, is

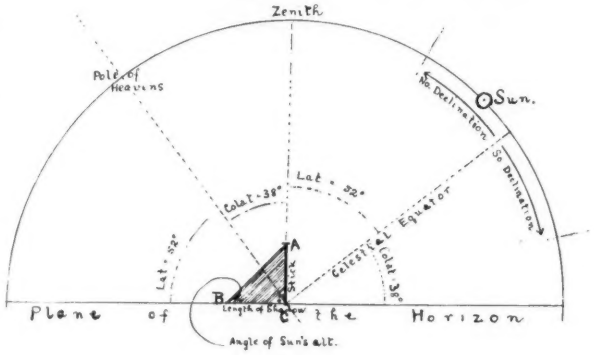


FIGURE 1.

similar to that used to find time at sea except that a sextant is used to measure the altitude of the Sun instead of the ratio of the length of a stick to its shadow.

(2) In the latitude of London the length of a perpendicular stick is equal to the length of its shadow at noon at about 9th April and 5th September of each year. The reason is apparent from a study of the figure. With the sun on the meridian and with the stick and its shadow of equal lengths we have, by elementary geometry, the angle ABC=45°, which must be the altitude of the Sun at noon. Now the colatitude of London is about 38° (see Figure 1) so that the Sun will require to have a northerly declination of 7° to make its meridian altitude=45° and the Sun's declination has such a value on the dates mentioned.

(3) The latitude of any place can be found, if the ratio of the length of the stick to its shadow at noon is known (the Sun's declination being also known approximately), for by the first answer the altitude of the Sun can be found from the given data, and by the figure it is seen that the latitude when the Sun is north of the celestial equator is equal to its zenith distance (*i.e.*, its altitude subtracted from 90°) added to the northerly declination, and when south, the latitude is equal to the Sun's zenith distance minus the southerly declination.

Note.—In the figure the length of the stick is drawn out of all proportion to the other lines. The stick, if drawn to scale, would require to be represented by an infinitesimal line on an infinitely small earth situated at the centre of the celestial sphere, half of which is shown.

THOS. R. ADLAM.

30. To find the time of the day by comparing the ratio between the length of a stick and that of its shadow involves the solution of a spherical triangle.

The formula for determining the hour angle is as follows:—

$$\sin\frac{h}{2}=\sqrt{\left\{\frac{\cos\frac{1}{2}(\phi+\Delta+a)\ \sin\frac{1}{2}(\phi+\Delta-a)}{\cos\phi\ \sin\Delta}\right\}}$$

where ϕ is the latitude, Δ the polar distance of the Sun, or 90 − declination, a the altitude, and h the hour angle.

If the ratio of the length of a stick to that of its shadow is $\frac{1}{2}$, the tangent of the angle of elevation is ·5, and $\alpha = 26° 34'$. Now, on May 1st the Sun's declination is 14° 49′ N., or $\Delta = 90 - 14° 49' = 75° 11'$.

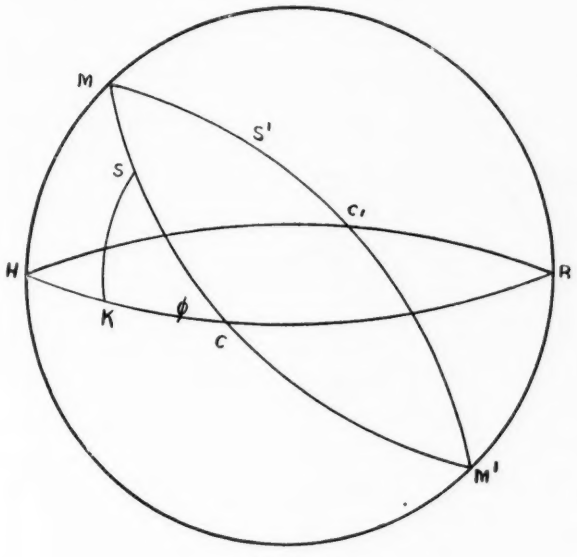


FIGURE 1.

ϕ, the Latitude of London is 51° 31′ nearly.
Making these substitutions we find that

$$\sin \frac{h}{2} = \cdot 5436$$

$$\frac{h}{2} = 32° 56' \text{ nearly.}$$

$$h = 65° 52'$$
$$= 65° \cdot 866$$

Hence, the number of hours before or after the Sun has crossed the Meridian is

$$\frac{65 \cdot 866}{15} = 4 \cdot 39$$

or $4^h. 23^m.$

Hence the time is about 7.37 a.m. or 4.23 p.m.

The Sun will attain nearly the same declination on August 13th, so that the same ratio between the length of a stick and that of its shadow would hold at the above times on this date.

To solve the second part of the question, finding the dates when the length of a stick and that of its shadow are equal at noon in Latitude London, we have the well known equation

Colat. ± Dec. = Meridian Altitude.

Where Colat. = 90 − Lat. = 90 − 51° 31′
= 38° 29′

In this case M.A. = 45°, since the tangent of the angle of elevation is 1.

Hence Dec. = 45° − 38° 29′ North.
= 6° 31′ N.

The Sun attains this Declination about April 7th and September 7th. On these two dates, therefore, the length of the shadow will be equal to that of the stick at noon, in Latitude of London.

To find the Latitude, assuming we know the ratio between the length of a stick and that of its shadow at noon on April 20th.

Suppose a stick 7-ft. 1-in. high cast a shadow 6-ft. long at noon.

If α be the angle of elevation, $\tan \alpha = \frac{85}{72}$

$= 1 \cdot 1805$. $\therefore \alpha = 49° 44'$

Now, on April 20th, the Declination of the Sun is 11° 13′ N.

Colat. ± Dec = Meridian Altitude.

$\therefore$ Colat. = 49° 44′ − 11° 13′
= 38° 31′

Hence Latitude is 90° − 38° 31′
= 51° 29

or, about the Latitude of London.

On August 24th, the Sun attains nearly the same declination, so that this ratio would hold on that date also. It should be noted that the time found in the first part of the question will be apparent time. The mean time, or clock time, is found from it by the equation, Mean Time — Apparent Time = Equation of Time. As, however, the equation of time is never more than sixteen minutes, there is no considerable error in taking the two as coinciding. On none of the dates given above does the equation of time amount to five minutes.

(REV.) M. DAVIDSON.

30. In answer to Question 30, of "Interested" (March issue of "KNOWLEDGE"), may I suggest the following as possible solutions to the queries therein mentioned?

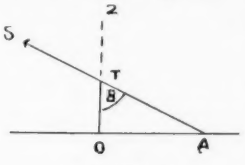


FIGURE 1.

(1) How can the time of day be ascertained by measuring the ratio of the length of a stick to that of its shadow on a given date?

In Figure 1, O T represents the stick, O A the length of the shadow of the stick cast by the Sun, O Z the zenith.

Then

$$\tan^{-1} \frac{O A}{O T} = \text{Sun's zenith distance at instant of observation.}$$

In Figure 2, E H W is the horizon, E Q W is the equator, P the celestial pole, Z the zenith, S the Sun.

S Z = Sun's zenith distance (found by means of the stick).

Z P = Colatitude = (90° − 51° 30′) = 38° 30′. (If London is the place of observation).

S P = Sun's North Polar distance = 90° − Sun's Decl. (found from almanac on given date).

< S Z M = Sun's Azimuth, *i.e.*, Sun's angular distance from Meridian measured from the north point, through E S H W.

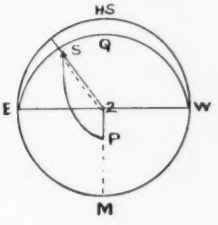


FIGURE 2.

Then from Spherical triangle S Z P.

$$\frac{\text{Sin S P Z}}{\text{Sin S Z}} = \frac{\text{Sin S Z P}}{\text{Sin S P}} \quad \therefore \text{Sin S P Z} = \frac{\text{Sin S Z}}{\text{Sin S P}} \text{Sin S Z P}$$

and this gives the Sun's Eastern or Western hour angle according as the observation is before or after noon. If the observation is before noon, 12 − Sun's hour angle gives the approximate time. If after noon the time is given by Sun's hour angle alone.

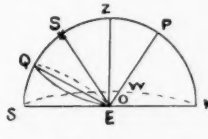


FIGURE 3.

(2) At what times in the year will the length of stick be the same as that of its shadow at noon? (Latitude of London.)

When the length of shadow equals length of stick the Sun's zenith distance is then 45° and 51° 30′ − 45°, gives the Sun's declination at the required times $\therefore$ Sun's Declination = 6° 30′.

From the almanac we find that the Sun's declination has this value on the 7th April, and the 7th September.

(3) Can the latitude of a place be determined by comparing the ratio between the length of a stick and that of its shadow at noon?

Sun's zenith distance at noon

$$= \tan^{-1} \frac{\text{length of shadow}}{\text{length of stick}} = \text{< ZOS}$$

Sun's Declination = < Q O S, (E Q W represents the equator) (P the pole) and < Q O Z = Latitude required.

Latitude = < S O Q + < S O Z.

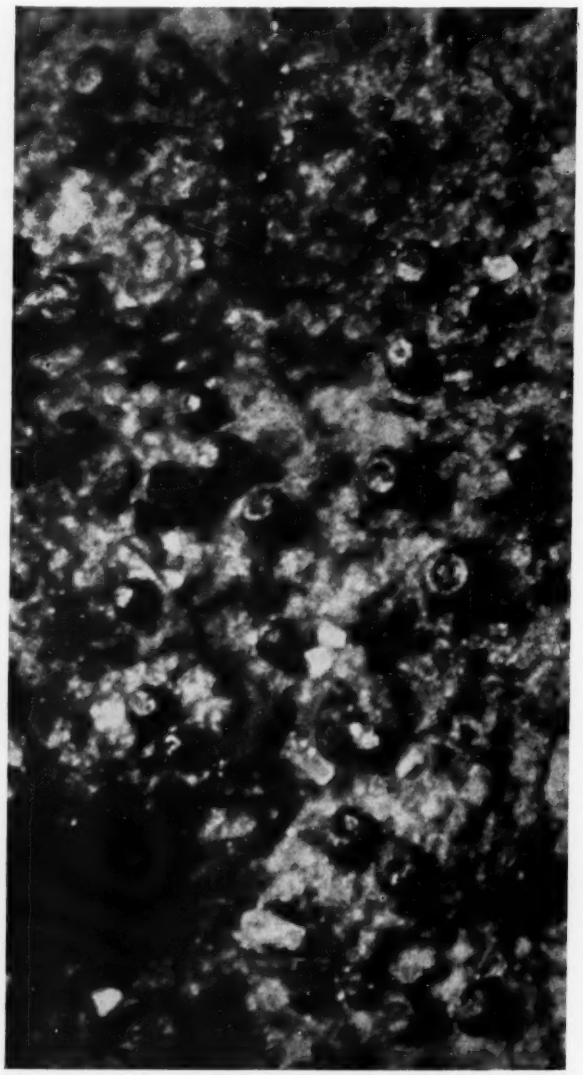
L. O. G. P.

A NEW LICHEN, *GONGYLIA VIRIDIS* A.L.Sm., IN SURREY AND ESSEX.

By ROBERT PAULSON, F.R.M.S.

A NEW lichen growing on the sandy bank of a footpath in the neighbourhood of Horsley, Surrey, and named by Miss A. Lorrain Smith, *Gongylia viridis*, was first collected by Mr. B. W. J. Starling, in February, 1910. Since that date it has been recorded by Mr. Percy Thompson from three separate localities of Epping Forest, all in the vicinity of Loughton and Theydon Bois. It has again, quite recently, been gathered from another spot in Surrey, by Mr. Starling. The finding of this lichen in Epping Forest was not a result of the discovery in Surrey, as it was sent for identification with other material that had been collected, both at the Essex Field Club Lichen and Moss Foray held in November last and at periods previous to that date. It was, most probably, first collected in the Forest in April, 1910.

There is little matter for surprise that this plant has hitherto been overlooked, for its thin, green, crustaceous thallus grows upon the ground and takes, as it spreads over the surface, all the irregularities of the soil. To anyone standing erect it appears as a green discoloration of the ground similar to that given by algae in damp places. It might easily be passed over, when not fertile, as the immature thallus of *Boeomyces roseus*. The sandy bank at Horsley has a southern aspect, so that the plant is fully exposed to the sun, there being little or no shade there. In Epping Forest this lichen occurs on sandy soil around gravel pits, and in one case it is on the perpendicular face of the digging, but all the Forest localities are more or less shady, thus showing that an exposed sunny situation is not essential, as might have been inferred if the Surrey plant alone had been found.



From a photograph *by A. W. Dennis.*

FIGURE 1. *Gongylia viridis* A.L.Sm.

Magnified twenty-five times.

The genus *Gongylia* belongs to the Verrucariaceae and has representatives in North and Central Europe; it is now, for the first time, included in the flora of Great Britain. The accompanying photograph by Mr. A. W. Dennis shows the chief characters of this plant, viz.: the thin thallus, exhibiting all the roughness of the ground, and the numerous globose, shining, black fruits, *perithecia*, with a depression at the top of each. Microscopic examination is necessary to make out other important characters of this species. The size and shape of the spores must be known for the purposes of exact determination. The fertile period is apparently at its best during the early months of the year.

Interesting questions arise respecting the present distribution of this plant, such as: How wide a range has it in the southern counties? Does it extend farther north than Essex? It should be looked for on sandy banks and mounds, both in sunny and more or less shady spots. Epping Forest would appear to most lichenists as a very unlikely locality for a new plant.

The diagnosis of *Gongylia viridis* appeared for the first time in the *Journal of Botany*, Volume 49, February, 1911, and it was discovered just in time to be included in the second volume of the Monograph of British Lichens which has been prepared by Miss A. Lorrain Smith, F.L.S., and printed, 1911, by order of the Trustees of the British Museum.

NOTES.

ASTRONOMY.

By A. C. D. Crommelin, D.Sc.

THE GYRO-COMPASS.—This instrument was described at the recent meetings of both the Royal Astronomical Society and the British Astronomical Association. It may claim a distinct astronomical interest from the close relationship that has always existed between Astronomy and Navigation, and also because it points to the astronomical instead of the magnetic north, its driving force being entirely non-magnetic, and arising from the earth's rotation. The benefit from the navigational point of view is fairly obvious, for not only is the magnetic deviation different for every point, but even at the same point it undergoes a slow secular change, so that the values marked on the charts need to be continually revised; there is the further obviation of all magnetic difficulties arising from the iron in the ship. This trouble had been partially corrected by Airy by the use of compensation magnets, but there was still a residual effect due to the change in the ship's magnetism when she changed her course, and so on. The driving force in the new compass is sufficiently powerful to enable a gearing-up arrangement to be used, an inner card giving angular deviations thirty-six times those of the outer one, or an entire revolution for 10°, so that a change of course of a small fraction of a degree is rendered manifest; further, the readings of a single compass (which in the case of warships can be placed in a secure position below the water-line) can be electrically reproduced on dials in various parts of the ship. There is a very ingenious arrangement for damping the oscillations from true north by the changing effect of an air jet escaping from the box containing the gyroscope. A diagram was shown in which the compass was pointing some 50° from north when the gyroscope was started. It only took a few minutes to find the meridian within a few degrees; swings continually diminishing in amplitude took place till after four hours they became insensible. The gyroscope should be started a few hours before the commencement of a voyage. It is turned by an electromotor; hence a current of electricity is required, but this is now available on all large ships.

It is of interest to compare this instrument with that devised by Foucault to demonstrate the earth's rotation. This was in addition to his well-known pendulum experiment, which was repeated at the Pantheon a few years ago. His gyroscope had freedom in all three axes, and thus, as Proctor pointed out in "Old and New Astronomy" page 236, it behaved "like an independent planetary body with its own proper polar axis directed constantly to the same point of the celestial sphere." The gyro-compass has not so much freedom, being suspended pendulum-wise by means of a float in a mercury trough. The idea of giving it complete freedom was considered, but abandoned, as it was found to be almost impossible to obtain such perfect balance about each axis that it could be depended upon to keep its direction in space for any length of time. Foucault's principle was practically used by Professor Piazzi Smyth on his voyage to Teneriffe, described in "Teneriffe, an Astronomer's Experiment." A telescope was mounted on board ship attached to a Foucault gyroscope, and it was found that celestial objects were kept for some time in the field, in spite of the rotation of the earth and the rolling of the ship. Unfortunately the flywheel was unequal to the strain, and gave way before long, but sufficient was done to illustrate the principle.

THE APPLICATION OF PHOTOGRAPHY TO FUNDAMENTAL ASTRONOMY.—Since the introduction of astronomical photography, many minds have been at work in the endeavour to apply the new method to astronomy of position. Of course the difficulty is that either the plates cover only a very small region of the sky, or they are of too small a scale to give accurate positions. Hitherto most of the methods suggested to give results over more extended regions have made use of the existing Transit-Circle, simply substituting photography for visual work at some of the stages. Professor Turner proposed some new methods in a paper read before the Royal Astronomical Society in March, which gave rise to an interesting discussion. His proposals do not aim at the independent formation of an entirely new catalogue of stars, but (1) to obtain differential places of further faint stars with the aid of the existing places of the brighter stars in the same zone, and (2) to detect systematic errors in the existing catalogues, such as the large error of a periodic kind that formerly affected the Greenwich clock stars, and which apparently has not even now been wholly removed. For the first problem he suggests the use of a coelostat reflecting a region of the sky into a fixed horizontal telescope. At the same time a small beam of light from a fixed source is made to fall on the coelostat and thence on the plate. This beam can be occulted by the clock pendulum at each swing, and thus serves as a time record. An exposure is given sufficient to record stars down to the tenth magnitude or so. After ten minutes (say) the coelostat is moved back to the first position and the process repeated. This can be done as often as desired till there are pictures of (say) twenty regions on the plate, all of the same declination, and differing in Right Ascension by known amounts. There will in the end be enough known stars on the plate to obtain good differential positions of all the stars on it. And it is claimed that the labour and expense would be far smaller than if all were observed with the transit-circle.

For the second problem he suggests the use of two horizontal telescopes at right angles, both facing a fixed mirror. Two fiducial marks in the two telescopes, exactly 90° apart, are found by simultaneous observations of the marks and their reflections in the successive faces of a silvered cube, in the place subsequently occupied by the mirror. Simultaneous photographs of two regions in the sky 90° apart are then taken, the following being done by moving the plates, not the mirror. The correction for refraction is discussed, and shown to be nearly constant if the altitude of the two regions is the same. It is pointed out that for observatories in high latitudes the most suitable study would be the observation of regions of the same declination, 90° apart in Right Ascension, while for equatorial ones, stars near the equator and poles might usefully be compared, thus checking our system of fundamental declinations.

Professor Turner has obtained a Government grant for prosecuting experiments of the kind here briefly indicated, and the results will be awaited with interest.

MARS.—Professor Lowell writes to me pointing out that he had previously used the method of shift due to motion in the line of sight, in the endeavour to separate the lines of Martian and terrestrial water-vapour in the spectrum of Mars (*vide* "Knowledge" for February). Like Professor Campbell, he did not succeed in getting definite results from the method, and found the comparison of the Martian spectrum with that of the moon more suitable.

A series of glass positives of this planet, taken by Professor Barnard with the great Yerkes Refractor, were exhibited at the R.A.S., and are reproduced (necessarily with some loss of detail) in the *Monthly Notices* for March. These photographs are on a larger scale than those taken at Flagstaff, and are, I think, superior to these in the delineation of the dusky regions (the so-called Seas) of which the outlines are very sharply shown, also the various depths of shading in different parts. They do not, however, show as many canaliform markings as the Flagstaff ones, though a few are indubitably shown. The extreme narrowness of these markings makes them very liable to be affected by bad definition, and that at Yerkes is said to be inferior to that at Flagstaff, which was carefully selected for this very purpose, and is at an altitude of seven thousand feet, surrounded by a desert.

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BOTANY.

By PROFESSOR F. CAVERS, D.Sc., F.L.S.

"SOIL WAX" AND SOIL FERTILITY.—In the first of a series of papers entitled "Contributions to our Knowledge of Soil Fertility" (*Proc. Linn. Soc., N. S. Wales*, 1910), Greig-Smith gives an interesting account of observations on the action of wax-solvents and the presence of thermolabile bacteriotoxins in soil. Water extracts from soil a substance which is toxic to bacteria, the toxicity of the extract being made evident by the retardation of growth, or even the destruction of the bacteria. The toxin is destroyed by heat, by sunlight, and by storage; it slowly disappears from air-dried soil, and rapidly decays in aqueous solution; it is not destroyed by salts such as sodium chloride or potassium sulphate. Soils vary in the amount of toxin they contain, good soils containing less, poor soils more. The particles of soil are covered or "waterproofed" by soil-wax, or "agricere," and various wax solvents such as volatile disinfectants increase the fertility of the soil by removing this "waterproofing," when the nutrient substances in the soil are more easily dissolved by soil-water and attacked by bacteria.

From the results of Greig-Smith's work, it is clear that the problems of soil fertility are very far from being solved yet. Doubtless further research will throw light upon such questions as the origin of the toxins and of the soil-wax, whether or not the protozoa occurring in soils have any real importance in soil fertility, and so on.

GRAFT HYBRIDS AND CHIMAERAS.—Some remarkable discoveries have been made during the last few years as the result of research on "graft hybrids" and allied forms.

Until 1907, only three so-called graft hybrids were known. The most familiar is Adam's Laburnum (*Laburnum Adami*), obtained in 1825 by M. Adam, a French horticulturist. Adam grafted *Cytisus purpureus*, a small tufted species, on the common Laburnum, and obtained a shoot with intermediate characters, which was readily propagated by grafting and by cuttings, and has long been in cultivation. A second remarkable form is "Crataegomespilus," supposed to be a graft hybrid between the hawthorn *Crataegus monogyna* and the medlar *Mespilus germanica;* the original tree is said to exist still in Lorraine. The third case is that of the Bizzaria orange, believed to have arisen through the inter-grafting of *Citrus Aurantium* and *Citrus medica*.

In 1907, Winkler (*Ber. deutsch. bot. Ges.*, Band 25) grafted a scion of *Solanum nigrum* (the common weed, black nightshade) on *S. Lycopersicum* (tomato), and after growth was resumed, a transverse cut was made across both stock and scion, in the hope that adventitious shoots would grow from the cut surface along the line of contact of stock and scion. Such shoots did actually appear, and in one case the new shoot involved tissues of both stock and scion, but this was clearly not a graft hybrid—one side of the shoot was *Solanum nigrum* and the other was *Solanum Lycopersicum!* To this peculiar structure, Winkler gave the name "Chimaera"; so sharply marked was the line between nightshade and tomato that some leaves were partly of one species and partly of the other.

In 1908 (*Ibid.*, Band 26) Winkler obtained an apparently true graft hybrid, which he named *Solanum tubingense*. Out of about two hundred and seventy grafts between tomato and nightshade, there arose over three thousand shoots, among which there were five chimaeras and the supposed graft hybrid *Solanum tubingense*; the latter, while intermediate in character, is rather closer to the nightshade than to the tomato.

In 1909 Winkler (*Zeitschr. für Bot.*), obtained several further "graft hybrids" by using the same methods. To the four varieties of these forms he gave the names *Solanum Darwinianum*, *S. Gaertnerianum*, *S. proteus*, and *S. Koelreuterianum*; the first two resemble the nightshade more than the tomato, the last two are closer to the tomato. Some of the new forms appeared as branches from chimaeras; some of them arose several times in the cultures. In a more recent paper (*Zeitschr. für Bot.* 1910), Winkler has reported the results of a study of the progeny of these new forms, with some interesting details. The vegetable shoots seem able to fuse and merge readily in various ways, yet the tomato and nightshade cannot be hybridised sexually. The "graft hybrids" without exception revert to the nearer parent, the seedlings of *S. tubingense*, *S. Darwinianum*, and *S. Gaertnerianum* being always *S. nigrum*, while the seedlings of *S. proteus* and *S. Koelreuterianum* always are *S. Lycopersicum*. The new forms may be hybridised sexually with the nearest parent form, the progeny being pure nightshade or tomato as the case may be. Moreover, reversion in the vegetative shoots is always to the nearer parent form. It is to be noted that the behaviour of the new *Solanum* forms is exactly like that of *Laburnum Adami*, which often shows vegetative reversion to one of the parent forms, and whose seeds give rise not to *L. Adami* but to *L. vulgare*.

Before proceeding to consider the interpretations of these very remarkable results, we may briefly summarise some still more extraordinary discoveries made by Erwin Baur. In Baur's first paper (*Zeit. Abstr. Vererbungslehre*, Band 1, 1909) he described the minute structure of geraniums with white-edged leaves (gardeners' "albo-marginate varieties"), and found that the green cells and the colourless cells are each descended from others of their kind, the external portions (comprising two or three rows of cells) being colourless and the internal portions green, and the limits between them very sharp. Since the sexual cells are derived from the external white layers, the seedlings give pure white forms. White branches give only white forms vegetatively, and green branches green forms only. If a pure white and a pure green be hybridised sexually, there arise green-white mosaic forms in addition to pure white and pure green forms. If in the mosaic forms the growing-point is situated on the line between the white and green portions, there results a chimaera, such as Winkler obtained so often in *Solanum*. In a cross section of the stem the two components appear as sectors, hence Baur calls such forms *sectorial chimaeras*. For the condition found in an ordinary *Pelargonium* with white-edged leaves, Baur proposed the term *periclinal chimaera*, one of the components investing the other; the growing-point is periclinally divided into white and green cells, the white being outermost, so that the entire plant consists of a body of green geranium invested by a mantle, two or three cells deep, of white geranium!

In a recent paper, Baur (*Biol. Centralbl.*, Band 30, 1910) notes his discovery that "Crataegomespilus" is a periclinal chimaera, consisting of a *Crataegus* body with a *Mespilus* investing layer either one cell in thickness (epidermis) or two cells deep. Baur solves the riddle of *Laburnum Adami*, finding that it also is a periclinal chimaera, with an epidermis of *Cytisus purpureus* covering a body of *Laburnum vulgare;* seedlings are always the latter, simply because the hypodermal layer, which produces the sexual cells, is of that species! When the outer layer consists of two or more layers of cells, the seedlings are of the peripheral species, as in *Pelargonium*.

Baur's astonishing discovery was almost anticipated in 1895, by Macfarlane (*Trans. Royal Soc. Edinburgh*, Vol. 37), who made a careful anatomical study of *Laburnum Adami* and in his figures showed clearly that this form agrees with *Cytisus purpureus* as to its epidermis and with *Laburnum vulgare* as to its internal tissues. Macfarlane, however, did not appreciate the meaning and importance of his own observations. In one of his latest papers, Winkler has re-investigated his *Solanum* forms in the light of Baur's epoch-making work, and finds that for the greater part they are, as Baur had suggested, periclinal chimaeras. Winkler supposes that what have been taken to be graft hybrids may be actual graft hybrids, resulting from fusion of the cells of different species; or they may have a hybrid nature owing to the migration between stock and scion of various substances

as atropin or nicotin in Solanaceae; or again they may be chimaeras—sectorial, periclinal, or some other kind. Careful study shows that *Solanum tubingense*, *S. proteus*, *S. Koelreuterianum*, and *S. Gaertnerianum* are periclinal chimaeras. Of these forms, *S. tubingense* has a nightshade body and a tomato epidermis; *S. Koelreuterianum* has the reverse relation of the two components; *S. proteus* has a tomato periphery of two layers of cells, while *S. Gaertnerianum* apparently has the reverse relation. Winkler thinks, however, that in *S. Darwinianum* he has a true graft hybrid produced by fusion of the vegetative cells of the nightshade and tomato. If this proves to be correct, it will be the first experimentally produced graft hybrid, and the only instance of such a form so far obtained.

The wonderful discoveries of Winkler and Baur, which do not appear as yet to have attracted attention in this country, break new ground and open up a new field of experimental biology. To both writers belongs equally the credit due to the pioneer in a new branch of investigation. The bearing of these discoveries upon theories of inheritance, and in particular upon the function of the nucleus in heredity, brings us to the cytological aspect of graft hybrids and chimaeras. In 1905 and 1907, Strasburger (*Jahrb. für wiss. Bot.*, Band 42, Band 44) investigated *Laburnum Adami* from this point of view. If this form is really a hybrid—owing its origin to fusion of the nuclei of *Laburnum vulgare* and *Cytisus purpureus*—then its nuclei should contain a number of chromosomes equalling the sum of the numbers characteristic of the two parent species. This is not the case, however, and Strasburger regarded this fact as evidence against the hybrid character of the graft. He also investigated forms obtained by grafting tomato and nightshade, and found that there was no migration of nuclei and no fusion of the nuclei of stock and scion; hence he concluded that Winkler's graft hybrids are merely chimaeras, calling them "hyperchimaeras"—forms in which the elements of the two parent forms are more or less intermingled but without any real nuclear fusion. Strasburger therefore denies emphatically the reality of graft hybrids, but as we have seen, Baur's results are of vastly greater importance than these cytological observations, and they enable us to place upon Winkler's work an interpretation different entirely from those made by either Winkler himself or Strasburger.

Strasburger goes on to consider the case of parasitism between Angiosperms; for instance, between mistletoe and its host plants, where there is an intimate relation between the two plants, but no mingling of nuclei. In grafting, a bud from the point of union might possibly give rise to a shoot bearing a flower in which an anther might be from the scion and an ovary might be from the stock; close fertilisation might then give rise to a true hybrid, but, Strasburger argues, hyperchimaeras would be more likely to produce flowers the seeds of which would give rise to pure plants of either the scion or the stock. The fact that pollen from his graft hybrids would cause fertilisation in tomato or nightshade, while neither of these plants can be crossed with the other, is regarded by Winkler as proof of true hybrid character; but Strasburger thinks that the pollen was probably pure, consequently fertilisation was to have been expected, but that only nightshade or tomato would result.

Winkler himself, in his account of the generation obtained from the seed of his hybrids, gives some results as to the chromosome numbers. In tomato the *X* (sexual) and *2X* (somatic) numbers are 12 and 24, while in nightshade they are 36 and 72. He suggests that the difference in chromosome numbers may prevent the crossing of the two species, though noting the fact that Rosenberg crossed two species of *Drosera* with 10 and 20 chromosomes in the sexual nuclei and obtained a hybrid with 30 chromosomes as the *2X* number. If the *Solanum* hybrids are due to fusion of somatic nuclei, they should have 72+24, or 96 chromosomes, unless the fusion should be followed by reduction, in which case the number would be 48. Winkler found the *X* number to be 36 in *S. tubingense*, *S. Darwinianum*, and *S. Gaertnerianum*, and found 12 in *S. proteus* and *S. Koelreuterianum*, the first three of these reverting in their pollen formation to nightshade and the other two reverting to tomato. Winkler suggests that the graft hybrids more closely resembling nightshade are from nightshade cells, and that those resembling tomato are from cells of that parent, the nuclei being like those of one parent or the other, but the protoplasm being mingled with that of neighbouring cells. This theory, implying that the protoplasm has great influence, obviously interferes with the now generally accepted view that the nucleus is the sole bearer of hereditary characters—but, as already stated, Baur's results probably make both Winkler's and Strasburger's explanations unnecessary.

Much further work is required both on the experimental production of graft hybrids and chimaeras, and the histological and cytological characters of these forms. In his most recent account of the cytology of the *Solanum* forms, Winkler (*Ber. deutsch. bot. Ges.*, 1910) states that *S. tubingense*, *S. proteus*, *S. Koelreuterianum*, and *S. Gaertnerianum* are periclinal hybrids; but that *S. Darwinianum*, at least in the subepidermal layer of the stem apex, is a fusion hybrid. The germ cells of *S. Darwinianum* have 48 chromosomes, and since the parents (tomato and nightshade) have 12 and 36 chromosomes as the *X* numbers, Winkler infers that the subepidermal layer from which the pollen is derived must have 48 chromosomes; he supposes that a nightshade cell with 24 chromosomes has fused with a tomato cell with 72, giving a nucleus with 96, and that in the progeny of this nucleus the number is reduced by halving.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (Oxon.), F.I.C.

SPONTANEOUS COMBUSTION OF COAL. — The various factors that tend to bring about the spontaneous combustion of coal have been made the subject of an experimental investigation by Messrs. Parr and Kressman, who have published their results in the *Journ. Ind. Eng. Chem.*, 1911, III, 151. They show that oxidation processes begin as soon as the coal is taken from the mine, and that when the temperature produced by external factors reaches a certain point, autoxidation sets in and results in the ultimate destruction of the coal. The average temperature for autoxidation lies between 200° and 275° C., according to the state of division of the coal, while ignition takes place at about 350° C.

The factors contributing to raise the temperature of the coal to the stage of autoxidation include: — (*a*) External sources of heat, such as sunlight, or impact due to the method of unloading; (*b*) Fineness of division; (*c*) Readily oxidisable compounds of a bituminous nature; (*d*) Iron pyrites, the presence of as little of which as five per cent. may raise the temperature by about 70° C.; (*e*) Moisture, which promotes the oxidation of the pyrites; (*f*) Oxidation of carbon and hydrogen, which takes place at temperatures above 120° to 140° C.; (*g*) The fourth or autogenous stage of oxidation.

Any measures to prevent spontaneous combustion must be based upon a consideration of these facts. All external sources of heat must be eliminated as far as possible, and all dust or finely divided material separated. Complete dryness in storage will prevent oxidation of iron pyrites, which is a fruitful source of danger in coal from the mid-American fields. No system of sorting at the mine can eliminate all risk from this source. Drenching the coal with water may increase the chances of oxidation where the sulphur is distributed throughout the whole mass, while complete submersion of the coal will probably not prove practicable. Preliminary heating might be used to bring about the initial stages of oxidation, and thus eliminate some of the factors which would subsequently supply the necessary heat for destructive oxidation processes. Treatment with chemical agents does not hold out much chance of success, but a system of circulating a cooling liquid through pipes distributed throughout the

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mass appears more promising. On the other hand, the formation of air passages, which is frequently advocated as a remedy, seems likely to do as much harm as good, since the heat of the oxidation promoted by the access of fresh oxygen may more than counter-balance the heat carried away by the air currents.

THE BLACK GLAZING ON GRECIAN POTTERY.—Many of the specimens of early Greek and Italian pottery have been coated with a fine black glazing upon a terra cotta ground, but the means employed to obtain this has long been a lost secret. According to M. A. Verneuil, who has recently published the results of his experiments upon the subject (*Comptes Rendus*, 1911, CLII, 380), the pottery has apparently been fired in an oxidising furnace; but the only way in which he was able to produce a similar black enamel, was by heating a flux containing magnetic oxide of iron in a reducing furnace. A mixture of iron filings, sodium carbonate and the powdered calcareous clay of the pottery itself yielded a flux, which when heated in an oxidising furnace produced a black glaze, which resembled the ancient black lustre in showing a greenish sheen in reflected light, but was not equal to it in depth of tone.

INFLUENCE OF CHROMIUM COMPOUNDS ON PLANTS.—An account of the experiments of Dr. P. Koenig, upon the influence of certain chromium salts upon plant life is given in the *Chem. Zentralblatt* (1911, I, 498). From these it appears that when applied in very small quantities chromium compounds, and especially chromous acetate, have a stimulating influence upon the germination and growth of plants, but that in large quantities their action is very toxic, and has a particularly injurious effect upon the roots. Solutions of chromates are the most poisonous, but their action may be minimised by adding an equivalent amount of lime to the liquid, or by the addition of salts of metals, such as silver or lead, which form insoluble chromates. In the case of plants, such as lupins, however, to which lime is injurious, the presence of the chromium intensifies the effect of the lime.

The degree of toxic action also varies with the composition of the plant, and the nature of the soil. Thus plants which contain much silica offer the greatest resistance to the action of chromates, while vegetation in a sandy soil is much more affected than that growing in loam, probably on account of the greater proportion in the latter of substances capable of combining with the chromate.

The amount of chromium taken up by the plant differs in the case of different compounds, and it is remarkable that alkali bichromates, which are the most toxic of the chromates, give up least chromium to plants. There is also a greater accumulation of chromium in the roots than in the other parts of the plant.

As the results of these experiments would indicate, a solution of potassium bichromate has proved very effective as a weed killer.

GEOLOGY.

By RUSSELL F. GWINNELL, B.Sc., A.R.C.S., F.G.S.

CLIMATE AND PHYSICAL CONDITIONS IN PRE-CAMBRIAN TIMES.—In the January—February number of the *Journal of Geology*, the oldest known rocks in Canada are dealt with by A. P. Coleman. Constituting the Keewatin Series in the west and the Grenville and Hastings Series in the east these pre-Huronian rocks stretch for one thousand miles across the country. The Huronian or Algonkian rocks, both sedimentary and eruptive, are already admitted to have been formed like rocks of later times. We find evidence in these early times of climates not unlike those of later ages, when wind and weather, flowing rivers, and beating waves and even great ice sheets did their regular work. In northern Ontario glaciers formed boulder-clay in latitude 46° showing no hint of the action of primeval heat such as the usually accepted version of the Nebular Hypothesis demands.

But there is much less certainty regarding pre-Huronian times. The world was already very old before the Huronian ice-sheets began their work. Many geologists have been inclined to see in the underlying "basal complex" portions of the earth's original crust, of plutonic rocks and crystalline schists consolidated from the cooling globe, which was still too hot to permit the condensation of water, so that no rivers or oceans were possible. The conviction, however, is growing in the minds of many geologists that, although the Huronian basal conglomerate means a break in *time*, it does not mean a break in the *continuity* of marine and terrestrial processes, but that the affairs of the world were conducted in the same way before this great interval as after it.

The author then shows that these pre-Huronian rocks include large amounts of sedimentary materials—limestones, dolomites, slates, gneisses having the composition of clayey sandstones, and so on. In the east the seas were clearer and deeper and limestones predominated, while in the west volcanic activity was very pronounced producing thousands of feet of ashes, and so on. There must have been great land-surfaces from which rivers flowed bringing down sand and clay. The sea contained plants to furnish the carbon (often reaching several per cent. in slates, gneisses and limestones) while the limestones hint at calcareous algae or animals having hard parts.

Similar sediments penetrated by granites and gneisses occur in the Lewisian of Scotland and in the Ladogian of Finland, and so on.

It is thus evident that the Keewatin and Grenville Series of America, like the oldest rocks of Europe, do not take us back to the commencement of geological time, since they include clastic sediments which imply the weathering and erosion of previous rocks before they were spread out on the sea bottom. "We have extended our outlook much farther into the past, but there is still an impenetrable background beyond. We shall perhaps never be able to say 'in the beginning'; but we may safely say that there is no hint of a molten earth in process of cooling down. If the earth was ever hot it had so far cooled down before the oldest known rocks were formed as to allow air and water and life to do their work in the world very much as they do now. If the earth ever passed through a period of great heat it was at a time too remote in the past to leave a geological record or to have any special interest for the geologist."

THE GEOLOGISTS' ASSOCIATION.—The Geologists' Association celebrated the fiftieth anniversary of its foundation by the publication of a useful work entitled "Geology in the Field: the Jubilee Volume of the Geologists' Association." This book, edited by Messrs. Monckton and Herries, has within the last few months been completed by the issue of Part V.

The places visited during the fifty years' existence of the Association were arranged in groups or districts, and a number of geologists, selected for their special knowledge of the localities, were asked to contribute descriptive articles on the respective districts, using the previously issued reports of the excursions as a basis. The scope of the work is confined, however, to England and Wales.

Hardly is this book completed before the work of the Geologists' Association comes once more before the general public. For, on behalf of the Association, Dr. J. W. Evans is arranging a series of exhibits in the Science Section of the Coronation Exhibition at Shepherd's Bush. These exhibits, intended to illustrate the work of the Geologists' Association, consist of maps and relief-models of districts visited and geological specimens collected by members from these districts. By the time these notes are published, the exhibition will probably be open.

A NEW INDUSTRY IN THE HEBRIDES.—The finding of iron ore in Raasay, one of the islands of the Inner Hebrides

lying in The Minch, between Skye and the Torridon district of the Ross-shire mainland, was announced late in the past year. The discovery was really made eighteen years ago by Mr. H. B. Woodward, F.R.S., in the course of his work on the Geological Survey, but the deposit has been recently investigated from a commercial point of view, and as a result the great firm of ironmasters and colliery owners, Messrs. Wm. Baird & Co., Ltd., of the Glasgow Coalfield, have bought the island. The deposit is situated at the junction of the Upper and Middle Lias, thus corresponding approximately with the position of the Cleveland ironstone. It is a ferruginous limestone forming a good basic ore. The deposit is from six to seventeen feet in thickness and probably many millions of tons will be available. Though it is not likely that blast furnaces will be erected on the island, for the ore will merely be calcined and then shipped to the South, still the opening up of mining operations in this quiet and remote spot will greatly alter the character of this district of grouse moor and deer forest.

This will not, however, be the only mineral industry carried on in that part of the Western Isles, for at two places on the adjacent coast of Skye, quarrying has been in operation on a comparatively small scale. The deposits of diatomite, a lake deposit consisting of the siliceous tests of minute plants, have been worked for many years in a wild, desert region north of Portree, and the calcined product shipped away for use in a multitude of industries—the manufacture of fireproof partitions, of tooth powder, of dynamite, of disinfectants, and so on. A beautiful white marble, somewhat like the Carrara stone, and produced by the metamorphic action of granite on Cambrian limestone, has been quarried intermittently near Broadford, and within the last four or five years systematic operations have been carried on, a mineral railway is now being constructed, and an export trade is being opened up.

THE PASSAGE OF LIGHT THROUGH CRYSTALS.—The issue of Dr. Tutton's popular account of the fascinating phenomena of crystallography ("Crystals." International Scientific Series, 1911), recalls his evening discourses before the British Association in Winnipeg, and the Royal Institution in London.

I had the good fortune to be present at the Royal Institution lecture, and shall never forget the wonderful experiments then performed. The most "showy" demonstration was an illustration of the fact that the light reaching the eye from a crystal is of two kinds, namely, white light reflected from the exterior faces and coloured light which has penetrated the crystal substance and emerges refracted and dispersed as spectra. Two powerful beams of light from a pair of widely separated electric lanterns were concentrated on a cluster of magnificent large diamonds arranged in the shape of a crown. The effect was not only to produce a blaze of colour about the diamonds themselves, but also to project upon the ceiling of the lecture theatre numerous images in white light of the poles of the electric arc, derived by reflection, interspersed with coloured spectra derived from the rays which had penetrated the diamonds and had suffered refraction and internal reflection.

The "Mitscherlich experiment," with gypsum, was also performed by Dr. Tutton. In this, a suitably-cut section of the mineral is shown with convergent polarised light, the resulting interference figure being projected on to a screen. At the ordinary temperature, the mineral is biaxial with a wide optic axial angle. As the crystal is heated gently this angle decreases, then closes up altogether (so that the mineral becomes uniaxial) and finally opens out again in a plane at right angles to the original optic axial plane. On allowing the crystal section to cool again the phenomena are repeated in the reverse order. No other mineral exhibits this phenomenon of crossed-axial-plane dispersion, by change of temperature alone, quite so well as gypsum. When one appreciated the significance of the interference figure as projected on the lecture-screen, admiration was called forth as there appeared first the usual lemniscates and rings around the two optic axes at the right and left margins of the field; then the axes approached one another and united in the centre of the field, the dark hyperbolic brushes combining to produce a rectangular cross, and the rings and lemniscates becoming circles; then the dark cross opened out again into brushes, but in the vertical direction, and the circles elongated out into ellipses and lemniscates again. Dr. Tutton's book deals with many other interesting crystallographic topics, such as the significance of isomorphism and dimorphism, the phenomena of "right- and left-handedness" in crystals, those peculiar optically-active liquids described as "liquid-crystals" and so on.

METEOROLOGY.

By JOHN A. CURTIS, F.R.MET.SOC.

THE weather of the week ended March 18th, as epitomised in the Weekly Weather Report issued by the Meteorological Office, was generally cold, wet and dull, with snow at many stations. Temperature was below the average in all districts.

Readings above 50° were reported only at Tottenham, Armagh, Killarney, and in the English Channel, the highest being 54° at Killarney and at Guernsey. The lowest minimum was 22° at Llangammarch Wells on the 17th, but readings below freezing-point were observed in all districts. The minimum on the grass was as low as 11° at Llangammarch Wells, and 18° at Plymouth. Rainfall was in excess, except in the North and West of Scotland, England N.W., and in Ireland; in some places the amounts collected were from three to four times as great as usual. The highest total reported was 1·93 inches at Hillington, Norfolk. Sunshine was in excess in Scotland and Ireland, but was generally in defect elsewhere. The sunniest station was Castlebay, Barra Island, with 51·9 hours (65%), while Deerness, still further to the North, but to the East, had only 2·3 hours (3%). Glasgow reported 28·7 hours (36%), while Eastbourne had only 17·9 hours (22%). The total duration of sunshine at Westminster was 9·1 hours (11%). The temperature of the sea-water varied from 48° at Seafield, to 37° at Cromarty. A thunderstorm was reported at Rothamsted and Raunds on the 13th; at the latter station it was accompanied by a violent snowstorm and great darkness.

The week ended March 25th was cool and unsettled, with snow in many places, and with thunderstorms in the S.E. and S. Temperature was above the average in England S.E. and in the English Channel, but was below the average elsewhere. The highest readings recorded were 63° at Tottenham on the 22nd, and 62° at Margate and at Guernsey. The lowest of the minima were 22° at Fort Augustus and at Balmoral. On the grass the minimum fell to 18° at Balmoral and to 19° at Llangammarch Wells. Rainfall was light as a rule, and in Scotland W. and Ireland N. the week was rainless. In Scotland N. the total district value was only 0·03 inch, or 1·00 inch below the average for the week; in England N.W. the amount was 0·04 inch, or 0·49 inch less than usual. Bright sunshine varied much in different localities, but was generally below the normal. Castlebay was again the sunniest station, with 54·7 hours (65%), Worthing coming next with 50·9 hours (61%). Sheffield had only 9·0 hours (11%); Westminster reported 19·9 hours (24%). The mean temperature of the sea ranged from 37°·5 at Cromarty to 47°·0 at Newquay.

The week ended April 1st, was dry, though cool and cloudy, but heavy rain commenced in the S.E. of England late on Saturday. Temperature was in excess in Scotland N. and England N.W., but was in defect in all other districts. The highest maximum reported was 63° at Arlington, N. Devon, on the the 30th, but in most of the districts the thermometer did not rise as high as 60°, and in England N.E. the maximum was only 51°, and at individual stations it was as low as 45°. The lowest readings for the week were 22° at Balmoral, and at Markree Castle, and 23° at Cromer. The minimum on the grass was 16° at Markree Castle.

Rainfall was below the average everywhere except in England

S.E., and the English Channel. At several of the stations the week was rainless. The amounts collected were as a rule small, but at Tunbridge Wells 1·22 inches was collected in three days. Sunshine was greatly in defect, except in Scotland N., and in England N.W., where it was slightly in excess. In England E. the district value was 12 hours (14%) as compared with an average of 34 hours (39%). The sunniest stations were Stornoway and Douglas, each with 39·6 hours (45%), while Guernsey reported 17·2 hours (20%), and Eastbourne only 11·7 hours (13%). At Westminster the total duration was 10·8 hours (12%). The mean temperature of the sea-water ranged from 38°·6 at Cromarty to 47°·4 at Newquay.

The week ended April 8th was very cold indeed, with but little sunshine. Much snow was experienced in the southern and eastern parts of England. Temperature was below the average everywhere. In England S.E. the mean was 36°·9, or 8°·3 below the normal, a lower mean temperature than had been recorded in this district, in the corresponding week, for thirty-four years. Only in Ireland and the English Channel was the district mean as high as 40°. The highest maximum (59°) was noted at Killarney, on the 2nd, and temperatures of 58° were also reported from Cullompton and Wick. The lowest readings came as a rule on the 6th, on which day a temperature of 17° was recorded at West Linton. Frost was reported at every station except Llandudno and Donaghadee. The lowest reading on the grass was 14° at Armagh and Markree. The total Rainfall was below the average in all districts except the English Channel, where it was just above the normal. At several stations the week was rainless, and in Scotland N. the total fall was only about one-twentieth of the average amount. Sunshine was deficient except in Scotland W. and England N.W. The sunniest stations were Valentia 54·7 hours (61%) and Falmouth 45·7 hours (51%). Westminster reported 26·0 hours (29%) and Birmingham only 10·3 hours (11%). The temperature of the sea-water varied from 37° at Scarborough to 50° at Scilly.

During the week ended April 15th, the weather was very fine in most parts of these Islands, but with a good deal of cloud in the North. Temperature was below the average except in England N.E., and in Scotland. During the first days of the week the maxima were very low generally, but a warm spell set in, and towards the close of the week temperatures of 65° and 66° were recorded. The highest maximum was 68° at Killarney on the 13th, but readings of 60° and upwards were reported from each district except Scotland W., and the English Channel. In the Channel Islands the maximum did not exceed 58°, and at Scilly it was only 55°. Frost was recorded in each district except the English Channel, and at Raunds and Llangammarch Wells the thermometer fell to 23°; at the latter station the thermometer on the grass went down to 15°. Rainfall was in defect in all parts, and many stations, including all those in England S.W., were rainless. Sunshine was below the average in Scotland and in England N.E., but above it elsewhere. Falmouth reported the greatest amount, 68·2 hours (73 %), and Fort Augustus the least, 14·1 hours (15 %). At Westminster the total duration was 34·7 hours (37 %). The temperature of the sea-water varied from 39° at Cromarty to 53° at Teelin.

WEATHER INSURANCE.—An interesting application of Meteorological Statistics for the purposes of Insurance is announced by the Excess Insurance Co., Ltd., which offers for a suitable premium to issue a "Pluvius Policy" under which an agreed amount of money will be paid to any holiday-maker, or other person, who experiences in any one week, over a specified period, more than two days of rain, amounting in each day to over 0·20 of an inch. The policy will in every case specify the place, the record of rainfall at which is to govern liability, together with an indication of the authority keeping the record. In most cases the authority will be the Town Clerk, or some observer recognized by the Meteorological Office. The rates are so arranged that a payment of £1 per week as premium will provide for £8 "compensation" should the rainfall amounts exceed 0·20 inch on more than two days during the week.

Policies must be taken out seven days before the period to be covered commences.

There are other forms of policy provided for, with varying rates, both of premium and of amount payable, but the underlying principle is the same in each.

An obvious objection to the scheme is that it provides "compensation" for loss or damage when no loss or damage has, in fact, been sustained; for, although a person whose holiday is interfered with by rainy weather may have to spend money in other and unexpected directions, and so suffer pecuniary loss owing to the rainfall, there is nothing in the scheme as announced to hinder anyone remaining, for instance, in London and claiming "compensation" for rainy days in Plymouth or Scarborough. In this way "insurance" may conceivably degenerate into gambling and prove harmful.

MICROSCOPY.

By A. W. SHEPPARD, F.R.M.S.,

with the assistance of the following microscopists:—

ARTHUR C. BANFIELD. ARTHUR EARLAND, F.R.M.S.
JAMES BURTON. RICHARD T. LEWIS, F.R.M.S.
THE REV. E. W. BOWELL, M.A. CHAS. F. ROUSSELET, F.R.M.S.
CHARLES H. CAFFYN. D. J. SCOURFIELD, F.Z.S., F.R.M.S.
C. D. SOAR, F.R.M.S.

LUMINOUS BACTERIA.—No phenomenon in nature is so striking as the production of light by living organisms; considered either from the scientific or the popular point of view it commands attention. The difficulty experienced in accounting for it is indicated by the fact that Darwin deals with it under the heading of "Special Difficulties of the Theory of Natural Selection."

Light production occurs principally among marine animals, but in these there are special organs involved. In the case of bacteria which are light-producing, it is difficult to suppose that special organs exist, they being minute uni-cellular bodies, consisting essentially of a mass of protoplasm enclosed in a cell wall; hence the possibility of a special light-producing organ is almost excluded. Light-production in living animals is essentially different from that of inert chemicals or of the phosphorescence produced by electrical means. Phosphorescent chemicals in all cases have the power of *absorbing* light and of re-emitting it either of the same, or of a somewhat greater wave-length. Bacteria emit light which is produced entirely by themselves, altogether independently of any extraneous light source; in fact, they grow and produce light better if kept entirely in the dark. In general, light can only be produced by raising the temperature of a suitable substance until it becomes luminous. It therefore follows that a great deal of the energy so converted is lost as heat; in fact, to such an extent is this the case that an ordinary electric lamp, even of the highest efficiency, does not give out in the form of light more than about five per cent. of the energy expended in raising the temperature of the filament. Bacteria produce light which is unaccompanied by any heat radiations, and so far as the investigations of the writer have yet proceeded, there is no evidence that any invisible radiations are produced by them at all. Their efficiency as light-producers is, therefore, extremely high, and were it possible to carry out on a commercial scale the process of light-production as it occurs in bacteria a tremendous step forward would be taken.

Essentially, the process is an oxidation one, as in addition to a nutritive material on which the bacteria may grow and reproduce, a supply of oxygen is necessary. The natural habitat of these organisms seems to be almost exclusively sea-water, or at least water such as is found in estuaries where an appreciable quantity of saline matter is present. They will grow and exhibit their light-producing properties on an ordinary peptone-beef-broth gelatin medium, but they do

not all emit the greatest possible amount of light unless an increased quantity of saline matter is present. It was recognized that probably in sea-water would be found the necessary constituents for an artificial medium, and after a series of experiments that which best suits them is found to be an ordinary gelatin one to which has been added 2·75 per cent. of sodium chloride, ·75 per cent. of potassium chloride, and ·25 per cent. of magnesium chloride. It is important that the medium should be neutral, or very slightly alkaline; an acid medium is entirely unsuitable for their growth.

FIGURE 1.

A flask photographed by the light of the bacteria within.

The most easily procured organism of this group is the *Photobacterium phosphorescens*. It may be obtained from a dead herring or mackerel. The fish should not be washed in fresh water after being caught. It should be placed in a closed receptacle, such as a large-sized Petri dish, for about twenty-four hours at approximately 20° C. At the end of this period there will probably be some spots which phosphoresce brightly. Plate cultures may be made from these spots, and in three to four days at ordinary room temperature the plates, on examination in the dark, will probably show some luminous colonies. Sub-cultures may be made from these, and the organisms may be kept going in artificial cultivations on the medium mentioned for several weeks without difficulty. Fish-broth or peptone-beef-broth may be substituted for a solid gelatin medium. It is necessary, however, if brightly luminous fluid cultures are required, to resort to some method of aëration, a supply of free oxygen being essential. In any case, when making fluid cultures, the media should be thoroughly well shaken up to ensure that as much oxygen as possible is present in solution before the organisms are inoculated into it. If the maximum amount of luminosity is aimed at, oxygen may be allowed to bubble slowly through the medium directly any luminosity appears, and although the period over which the light production occurs is thereby reduced, the luminosity is extremely brilliant while it lasts.

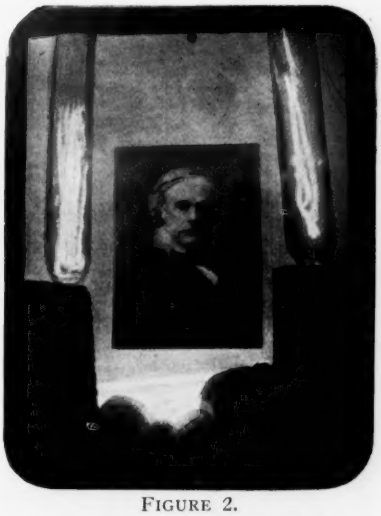

FIGURE 2.

A picture of Lord Lister illuminated by bacteria.

Figure 1 shows a flask of these organisms photographed by means of their own light, which will give some idea of the brilliancy to be obtained under these conditions.

Figure 2 is a photograph of Lord Lister, illuminated by means of growths on solid media. On each side will be seen tubes containing the organisms and several of them were placed underneath throwing the light upwards.

Figure 3 is an ordinary Petri dish with luminous colonies on it. These again were photographed entirely by their own light, the colonies standing out brilliantly on a dark back-ground. The exposure in photographing these organisms is always somewhat prolonged; although their visual luminosity is high yet their photographic action is not rapid, as the light emitted does not lie in that portion of the spectrum which is photographically most active. There is the further difficulty that the light happens to lie in a region of the spectrum to which photographic plates are particularly insensitive, so that due allowance must be made for these two factors if any attempt is made to obtain a photograph of these organisms by their own light.

FIGURE 3.

Colonies of bacteria on a Petri dish photographed by their own light.

Some twenty-five varieties of these organisms have been described, and it is also stated that other bacteria such as the *Cholera vibrio*, are known to produce light under certain conditions. Of these twenty-five described species it is more than likely that some are not really entitled to be regarded as distinct. A broad classification of them may be made by separating those that grow at low, and those that grow at a higher temperature. There are two or three species found in Northern latitudes that thrive and produce light at 0°C., whereas there are certain other varieties which grow in Southern latitudes, particularly in the Indian Ocean, that will go on producing light at a temperature of from 30°C to 35°C. The writer has had through his hands at various times some fourteen varieties, as well as one which there is reason to think is a new species, originally identified at the Marine Biological Laboratory, Plymouth. Morphologically the organisms vary widely: the common species *Photobacterium phosphorescens* already mentioned, is a short thick rod, which when grown on a medium containing more than three per cent. of saline matter assumes a much shorter, thicker appearance, and is almost coccoid in form. Nearly all varieties change considerably in form when artificially cultivated for long periods, so that it is often difficult to identify a particular species by its microscopic appearance. Owing also to the amount of saline matter necessary in the medium, the organisms

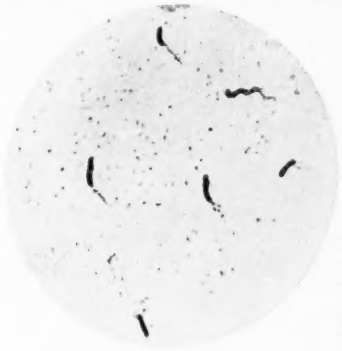

FIGURE 4.

Photobacterium balticum grown in fish-broth.

FIGURE 5.

Photobacterium balticum grown in peptone-beef-broth.

often develop vacuoles, and assume varied shapes. They all stain easily by most of the well-known bacteriological staining methods, and in most, if not all cases, a flagellum or flagella may be demonstrated.

Figures 4 and 5 show the marked differences that occur in some species under different methods of cultivation (*Photobacterium balticum*). Figure 4 is grown on a fluid fish-broth medium. Figure 5 is grown on peptone-beef-broth containing the maximum amount of saline matter that the organism will tolerate. In each case flagella are clearly shown.

The question whether the organism itself produces light as a direct metabolic process, or whether it is an extra-cellular bacterial product that is light-producing, is still an undetermined point; but all the evidence goes to show that the light production is undoubtedly associated with the life-history of the organism. By no experimental means has it as yet been possible to isolate the light-producing material from the actively-living cell.

These organisms may be recommended to the amateur microscopist as a most fascinating field of research, in which there are still many problems to be solved; they present no great cultural difficulties, nor do they require the resources of a bacteriological laboratory in which to carry them out.

J. EDWIN BARNARD, F.R.M.S.

ROYAL MICROSCOPICAL SOCIETY.—March 15th, 1911. Mr. H. G. Plimmer, F.R.S., president, in the chair. Dr. Ralph Vincent gave a lantern demonstration on "Some Photomicrographs illustrating the morphology of the organisms concerned in the production of acute intestinal toxaemia in infants." These included *Bacillus subtilis*, *B. mesentericus*, "No. 7," *B. mesentericus vulgatus*, and *B. proteus vulgaris*. The photographs showed the organisms stained, unstained and during life. Photographs were also shown of *Streptococcus lacticus*, *Bacillus acidi lactici* and *B. bulgaricus*.

Mr. F. W. Watson Baker contributed a paper on "Anomalies in Objective Screw Threads."

Mr. E. M. Nelson described a new piece of apparatus consisting of an objective mount fitted with an iris diaphragm, in which the iris was just clear of the back lens, and its movement was controlled by a collar adjustment. This piece of apparatus would no doubt be of great value to workers who employ dark-ground illumination for viewing bacteria, and so on, as in many instances, owing to defects in the illuminator, it was not possible to obtain a dark field when the objective had a wide angle. This fault was remedied by stopping down the aperture of the objective by means of the diaphragm. Mr. Nelson also described some new objectives and eye-pieces made by R. Winkel, of Göttingen, and contributed a short historical and descriptive résumé of the "Variable Microscope."

Mr. J. Murray brought forward a Report on the Rotifers collected by the British Antarctic Expedition of 1909. Forty-six Bdelloids were collected, bringing the Australian list up to fifty-four species. There were seven new species, and eight others occurred as distinct varieties. The new species were *Philodina australis*, *Callidina armillata*, *C. lepida*, *C. longistyla*, *C. serrulata*, *C. mirabilis* and *Habrotrocha strangulata*. The most aberrant form was *C. mirabilis*, which had peculiar fleshy processes on the trunk. The rotifera fauna of the Australian Alps resembled that of Britain. The arid lowlands were very unproductive. Three-fourths of the species, and all the new species, occurred in the Blue Mountains, at moderate elevations. Eight species of non-Bdelloid rotifera were also noted from the water supply and ponds in Sydney.

THE PREVENTION OF FADING OF ANILINE STAINED MICROSCOPIC PREPARATIONS.—In common with many microscopists I have found that films of blood, bacteria, and so on, when stained with almost any of the aniline dyes, fade after a time when mounted in Canada Balsam. This is especially the case with methylene green, thionin, methylene blue, or methylene blue and eosin, either separately or combined as Jenner's stain, and all the modifications of Romanowsky's valuable stain, *e.g.*, Giemsa, Leishmann, Wright.

There is no doubt but that the cause of fading in balsam-mounted preparations, judging from my own experience and from the expression of the opinion of numerous authorities on the subject, is acidity whether present at the time of mounting, or developing subsequently from oxidation of the mounting medium.

I will not enter into details of my experiments or the statement of the authorities as to the facts which lead me to the above conclusion. They have been described in full elsewhere, *Lancet*, 1911, Vol. I, page 876.

It may, I think, be stated that practically all substances of the nature of balsams, oleo-resins or cedar oil will sooner or later oxidise and become acid and, therefore, are liable to cause fading of the aniline stains.

It is not possible to obtain a neutral Canada Balsam that will remain neutral.

After numerous trials, I have found that *Paraffinum liquidum* is a neutral medium which does not undergo oxidation and, therefore, does not become acid.

I have used a pure form of liquid paraffin, namely Burroughs and Wellcome's "Parolein" and so far have found the results admirable. It is more trouble to mount in than a balsam, and the preparations require to be ringed or cemented round with some cement which is also neutral. The following is the method I use for mounting films of blood or bacteria which are spread and stained on the slide.

A perfectly cleaned cover-glass is held in a pair of forceps over the flame of a spirit lamp for a second or two to drive off any moisture on the glass, and is then laid on a clean sheet of notepaper. A very small drop of Parolein is placed on the centre of the cover-glass, and the slide with the blood film, after being slightly warmed over the flame, just enough to be sure that the glass is perfectly free from moisture, is gently let down on to the cover-glass. In a second the oil has run nearly to the margins by capillarity, and a little pressure on the cover-glass will send it completely to the margins. If the amount of oil is just sufficient to reach the margin of the cover-glass so much the better. If there is too much oil, the preparation is placed under a piece of blotting paper and the excess of oil pressed out as much as possible. One soon learns how much oil is required to make a clean preparation. A not uncommon thing is to find that the cover-glass rocks, that the oil has only covered about three parts of the square or circle. This is almost always due to the presence of a minute particle of dust between the cover-glass and slide, and is to be prevented by seeing that the cover-glass is quite clean and free from dust before placing the oil on it, and by just dusting gently the film surface on the slide. But usually it is easily remedied by running in a very small drop of Parolein at the margin of the coverglass.

To fix the cover-glass in position it is necessary to ring it round with some cement. The cement must be neutral or there will be fading, and the cement must withstand the action of the immersion cedar oil. I first ring round the preparation with Apathy's Gum Syrup made as follows: Picked gum arabic, cane sugar not candied, distilled water, of each, 50 grammes. Dissolve over a water bath and add 0·05 grammes of thymol. I test the reaction with litmus paper, and if acid I add a few drops of a solution of *Sodii carbonas*. If the cover-glass is round the cement can easily be applied on a turntable: if square, which I prefer, one paints it round with a very small brush. This sets in about fifteen to thirty minutes in a warm room. When dry I apply over it a coat of Bell's cement, which also dries quickly.

I should be glad to hear of any better cement, but whatever be its nature it must be neutral in reaction.

As regards the optical characters of Parolein, the refraction index is 1·471. That of solid Canada Balsam 1·538, that of balsam in xylol a little lower, say 1·530. The refraction index of bacteria is said, according to A. Fischer, to be 1·55.

XUM

Now the index of visibility or power of seeing an unstained, and presumably a stained, structure is greater when the medium has a very low or a very high refraction index.

Bacteria would be invisible in a medium having a refraction index of 1·55, in Canada Balsam they would be seen, in Parolein they would be seen much better, and this theoretical statement is borne out by experience. Very delicate structures like the flagella of bacteria are better seen in Parolein than in Canada Balsam.

Mr. E. M. Nelson and Mr. Merlin both state that the delicate structures, in some bacterial films I sent them, "are strong and sharp; in fact, stronger and sharper than in balsam."

I am not prepared to state that there is no better mounting medium than Parolein: I should only be too glad to hear of one that offers a reasonable chance of permanency and which has as good optical qualities. All I can say is that at present every slide that has a place in my cabinet will be mounted in Parolein; Canada Balsam has served me very badly.

ALFRED C. COLES, M.D., D.Sc., F.R.S. (Edin.),
M.R.C.P. (Lond.).

THE MICROLOGIST.—We have received from the publishers, Messrs. Flatters, Milborne & McKechnie, Ltd., of Manchester, Part 4 of their quarterly journal, *The Micrologist*. In this part full details are given for the preparation of slides illustrating the Marine Protozoa, chiefly the Radiolaria—such types as *Sphaerozoum*, *Aulacantha* and *Myxosphaera* being dealt with; in the latter case the method of infiltrating and cutting sections of the colony being described. The Amoeba, its life-history, structure, cultivation and the preparation of microscopical mounts, is dealt with by Mr. Gordon McKechnie. It would be an advantage if some indication were made as to what other organisms can be treated in the same manner as that described for Amoeba; for instance, would the same treatment suit *Paramoecium*, *Stentor*, and so on? Included in this number are formulae for stains and mounting media, which cannot fail to be of use to the working microscopist. Plate IV illustrates the objects dealt with and of the slides sent out with this number we have received two—*Amoeba* and *Sphaerozoum*—the latter making a very pretty object with a low-power and dark-ground illumination.

QUEKETT MICROSCOPICAL CLUB.—March 28th, 1911. Professor E. A. Minchin, M.A., President, in the chair. The death of Mr. W. M. Bywater, F.R.M.S., on March 1st, was announced. He was one of the founders of the Club, and its first secretary.—Mr. A. C. Banfield exhibited and described a new quartz mercury vapour lamp, manufactured by the Brush Electrical Company. The quartz tube used in the new form is about four inches in length. The lamp is extremely rich in ultra-violet rays, and will sterilize a Petri-dish cultivation in less than one minute. The peculiar mercury spectrum gives a unique opportunity of easily obtaining strictly monochromatic light in large quantity, with a choice of several wave-lengths, that at λ 5461 being the most powerful source of monochromatic light at present available.—Mr. E. M. Nelson, F.R.M.S., described the best method of obtaining dark-ground illumination. Place the bull's-eye at right angles to the edge of the flame. Adjust its height so that the horizontal optical axis of the bull's-eye cuts the brightest part of the edge of the flame. Focus the bull's-eye so that a sharp image of the flame is thrown upon a wall, distant, say, five feet. Place the lamp, without altering these adjustments, on the left-hand side of the microscope, and ten to twelve inches from the mirror; remove substage condenser and objective, and place a low-power eyepiece in position. Incline the plane mirror and adjust the height of the lamp so that the bright part of the flame falls centrally upon it. Then incline the mirror so that the full beam is reflected up the microscope tube. From a distance of six or eight inches look at the bright spot of light at the eye-lens. This should be an evenly-illuminated bright disc. Replace condenser and objective, centre and focus substage in usual manner and proceed with the work in hand, selecting a suitable black stop, one not too large, and a dark field of maximum brightness for that set of apparatus will have been obtained. To obtain the darkest possible ground many objectives require the tube-length to be increased, sometimes considerably. Mr. C. Lees Curties exhibited, at Mr. Nelson's request, the lamp and condenser described.—Mr. A. A. C. Eliot Merlin, F.R.M.S., discussed "Some New Diatomic Structure discovered with a new Zeiss apochromat."—Mr. James Murray, F.R.S.E., F.Z.S., read a paper, "Water Bears or Tardigrada." As the name Tardigrada is already appropriated by vertebrates the group is now classified as order Arctiscoida, family Xenomorphidae. The paper describes four new genera and their relationships, concluding with a synopsis of the ten genera and one hundred and twenty species at present admitted.—Mr. M. Ainslie exhibited and described a "finder" for the microscope, useful with powers up to about one-sixth of an inch. It consists of a hinged and pointed arm clamped to one corner of the stage. When it is wished to record the position of an observed object, the point is inked and allowed to make a mark on the label to the left of the object. It is intended for use with either a mechanical stage or sliding bar.

ORNITHOLOGY.

By HUGH BOYD WATT, M.B.O.U.

BIRDS FROM NEW GUINEA.—The newly arrived collection referred to in the last number of "KNOWLEDGE" was shown in the Board Room of the Natural History Museum, South Kensington, on the 5th April, and *The Times* of the following day gives a brief report on it. The collection includes eleven species and several dozen specimens of Birds of Paradise and their congeners of the crow and starling group. There are nine examples of the magnificent flame-coloured Bird of Paradise (*Xanthomelas ardens*) hitherto represented in Europe by only two specimens in Holland and an imperfect skin in Genoa. Amongst the larger birds is an ibis (much like the sacred ibis), and, in addition to the more distinctively tropical kinds mentioned last month, one or two sheldrakes and ducks. A familiar British bird occurs in the form of a young male common cuckoo taken in December last, presumably on migration from northern regions to Australia. The collection is very rich in the groups of smaller birds. The genera best represented are sunbirds, flower-peckers, honey-eaters, and flycatchers, also cuckoo-shrikes, ground-thrushes and bee-eaters. The material will enable the distribution of many species to be worked out better than hitherto; and results of even more importance are anticipated from the regions of the great snow mountains which the expedition hopes to attain, and where the avi-fauna is far less known than in that part of Dutch New Guinea from which the collection now under review has come.

A BLACK EGG.—In *The Field* of 25th March last, an egg uniformly black in colour is figured, sent by a correspondent from his duck-house, where ordinary wild ducks and others called by him "East Indians" are kept together. The last-named are described as black, with bottle-green on the wings and hackles, and are probably the Cayuga duck, which comes from South America. It is explained that eggs of this melanistic variety of duck sometimes partake of the colour of the plumage, but the black colouring does not penetrate the shell, being due to an oily pigment which can be rubbed off. After successive layings the colour fades and eventually disappears.

A NOVEL BAIT FOR WOOD-PIGEONS.—Intoxicants have recently been recommended and tried as an assistance in getting rid of the wood-pigeon pest. Mr. J. L. Courthope, M.P., suggests that corn be soaked in spirit and distributed in the feeding places of the birds, which will eat the grain, become intoxicated, and then be easily caught and killed. We believe that gin has been used in some such way in Herts, with effective results.

XUM

BIRDS IN LONDON AND THEREABOUTS.—Mr. A. Holte Macpherson contributes his welcome annual "Notes on London Birds" (1910) to *The Selborne Magazine* for April (pages 96–97). These notes have now continued for twenty-one years without a break, and are of much value as giving personal observations, mostly in the West-end parks. The literature of London birds is an extensive one, but it is to be hoped that Mr. Macpherson may be induced to publish a review or survey of his observations in a more permanent form. Instructive comparisons would not be a-wanting in it. In the course of 1910, a great crested grebe was seen on the Serpentine on 29th January, and another on the Round Pond, Kensington Gardens, on 11th July. Mr. Macpherson had only once seen this fine species in London previously, and points out that it is remarkable how it has increased near that city during the last few years. Virginia Water and Richmond Park are named as haunts of the bird, to which we would add Ruislip Reservoir. Greater London holds within its area the "Brent Valley Bird Sanctuary," an account of which is published in a small work under this title by Mr. Wilfred Mark Webb, Honorary Secretary of the Selborne Society, of which a third and revised edition, profusely illustrated, has just been issued (The Selborne Society, 42, Bloomsbury Square, London, W.C., 34 pages, price 6d., or in paper boards, 1/-). The Sanctuary has been maintained now for about six years with results which redound to the praise of the Committee who so vigilantly look after it, and are gratifying to all who care for our native birds. Nesting boxes, made on the spot, have been used since 1908 as a method of attracting birds and have proved quite successful, being largely used. Within this limited area of nineteen acres, possessing no outstanding natural advantages, thirty-six species (almost entirely smaller woodland birds) have now nested, and eighty-six species in all, including occasional visitors, have been observed in or close to the place.

A MIGRATION "RUSH."—The Irish newspapers report that a migratory movement of an extended character was observed on 29th–31st March, conspicuously in South-east Ireland. The weather conditions were still and dark, the moon being in her dark phase, and at the same time fog prevailed. These conditions are conducive to migrants showing themselves. The migrating flights seem to have been attracted by the lights of the towns, just as they often are by lighthouses. In New Ross a swarm of starlings descended on the town about ten o'clock and the streets were littered with them. House-windows were broken and numbers of birds entered the houses. In Kilkenny many hundreds of birds fell dead in the market-place and elsewhere. In Carlow the destruction which befel the birds is said to have been caused by them coming into contact with telegraph and other wires. Immense flocks of Curlew passed over this town on the night of 29th March, in a N.E. direction, being recognised by their shrill whistling.

The other kinds of birds named in the reports are thrushes, blackbirds, redwings, and sparrows, but, no doubt, many species were unrecognised. Amongst them probably occurred some of our first summer visitants for this season.

CROSSBILLS IN THE BRITISH ISLES.—An account of the irruption of crossbills which took place in 1909, is given in the April number of *British Birds* (Vol. IV. pages 326–331). First observed at Fair Isle, on 23rd June, 1909, the arrivals continued until about 10th August. The birds appeared rather later in southern districts than in the north, and by the latter part of July their numbers were decreasing in Scotland. In England they were much in evidence during July and increased until well into August. During the winter they were recorded from all the English counties except Cumberland, Notts, Huntingdon, Cambridge, Dorset, Devon and Cornwall; and in Wales from Denbigh, Merioneth, Montgomery and Brecon. It is remarked that records are far more numerous from the country lying to the south and east of a line drawn from the Wash to Portland Bill, the sandy soils occurring therein being much planted with pine trees. These trees provide natural food supply for the birds.

Nesting was recorded as early as 12th January, 1910, near Thetford, Norfolk (three nestlings), and the latest records are 25th May, from Sussex and Kent. All the nests known were in Scots pine, except two in spruce and two in larch. Only a small proportion of the visitants nested, the following counties yielding records, viz:—Kent, Sussex, Surrey, Hants, Berks, Essex (two), Suffolk, Norfolk, Somerset (one), Gloucester, and Staffs (one), also probably Lincoln and Bedford.

The departure of the birds began in the winter of 1909–10, and this movement was at its maximum from February to June, with a few records for later dates. The visitation thus extended over a period of rather more than twelve months.

It should be added that the bird spoken of is now designated by modern ornithologists as *Loxia curvirostra curvirostra* —the Common Crossbill.

Mr. H. F. Witherby follows the paper above summarized by an article (pp. 332–334) on its status as a British bird, of which the following is an abbreviated summary, viz.:—

ENGLAND AND WALES.—An early autumn immigrant (mid-June to August), irregular in most districts. Periodically (every three to ten years) arrives in great numbers, and becomes much more generally distributed, frequently staying over the following spring and into summer. Authentic records of nesting are so few and far between that the bird cannot be classed as a resident, but only as a migrant, breeding sporadically (nesting counties are named by Mr. Witherby). Crossbills have been found this spring (1911) to be breeding in localities in which they bred last year, the first time they are known to have nested in two successive years in the same district.

SCOTLAND.—Immigrant as in England, but not so regular. Breeds sporadically and rarely in Southern Scotland (counties named).

IRELAND.—Now resident but not indigenous. Apparently only migrates to Ireland in years of "irruptions." Following that of 1887-8 became established as a breeding bird.

The Scottish Crossbill, *Loxia curvirostra scotica* Hart, which is confined as a breeding bird to Scotland, is resident in Northern Scotland, where it breeds in certain localities (named). Has occurred sporadically in winter in very small numbers in Southern Scotland (counties named).

PHOTOGRAPHY.

By C. E. KENNETH MEES, D.Sc., F.C.S., F.R.P.S.

THE MEASUREMENT OF SURFACE BRIGHTNESS.—Under this title a paper was read at the Royal Photographic Society, on March 28th, 1911, by Messrs. J. S. Dow and V. H. Mackinney, describing a small portable photometer under the name of the "Holophane Lumeter," which is intended for the measurement of the intensity of the light reflected from various objects.

In the instrument, the surface whose brightness is to be measured is observed through an aperture in a white opaque surface, the discs surrounding the aperture being illuminated by means of an opal glass behind which is an Osram lamp, run off an accumulator. The area of the opal glass can be restricted to any required extent by means of black sectors, and the intensity of the illumination read to one per cent. by means of scales, the maximum opening representing an intensity of one foot candle.

The accuracy claimed for the instrument is about five per cent., which will clearly be sufficient for most practical purposes.

By means of two supplementary black glasses the light from the external surface can be cut down to one-tenth or one-hundredth of its original amount, and the maximum intensity measurable can thus be made ten or one hundred foot candles.

This range seems to me insufficient, and it would probably be better to add other densities to extend the scale to one thousand and ten thousand foot candles.

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The instrument, in use, appears to be very convenient, the greatest difficulty in photographic use, however, being due to the colour effect of daylight, which makes matching distinctly difficult. It is possible that this might be completely avoided by the aid of an orange screen to tint the daylight beam, but such a screen would require careful adjustment.

There are numerous directions in which such an instrument can be of use in photography; in the first place, it is obviously of importance to know the range of contrast which exists in photographic subjects, and this is a point on which hitherto experiments have been difficult to make, and on which views of considerable diversity have been expressed.

Messrs. Hurter and Driffield measured the maximum

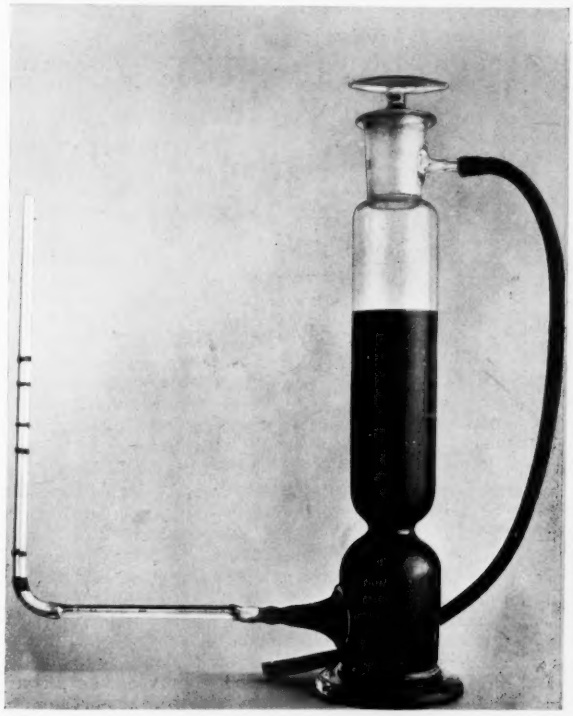

FIGURE 1.

difference of intensity in landscape subjects by taking a photograph of a scene in which was included a square of white cardboard in sunlight and a piece of black velvet in shadow; the plate was developed together with another plate from the same box which had been exposed behind a sector wheel to a candle, and the densities of the patches representing the white cardboard and the black velvet were measured and compared with the densities of the known exposures on the other plate. As a result the white cardboard in sunlight was found to reflect thirty times as much light as the black velvet in shadow.

In their paper, Messrs. Dow and Mackinney mentioned that the maximum range of intensity which they had measured in a subject between the brightest white magnesia and the darkest dead black which they had been able to obtain was as thirty to one; so that apparently the result obtained by Messrs. Hurter and Driffield for the maximum range in ordinary photographic work may be considered as confirmed.

Some measurements made by means of a similar, but much less convenient, portable photometer two or three years ago, gave the writer only one to four as the range of intensity in a street scene on a dull day, so that probably the range in most landscape photographs is of the order of one to eight or one to sixteen, a range which is capable of being represented within the "period of correct exposure" of a plate.

Another use for the instrument, suggested by the authors of the paper, was the finding of exposures, and although several speakers in the subsequent discussion considered that the variation in the actinic value of daylight would make the instrument of but little value in this direction, it seems to me that in some branches of photography it should prove of very great value indeed.

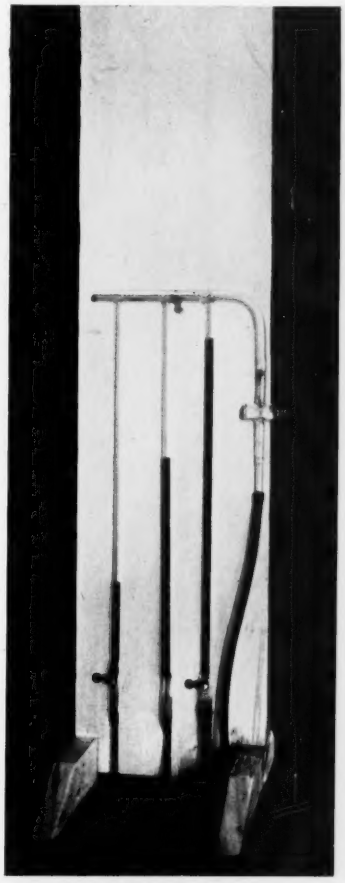

FIGURE 2.

While it is improbable that such an apparatus, which is necessarily of some size, will displace the handy and simple sensitive paper actinometer for landscape work, yet in the technical studio it has many advantages. In copying prints by daylight in this climate difficulty is often introduced by the rapid variation of the light while working; even if the first exposure prove quite correct on development, the light may change sufficiently to spoil it before a second exposure is made.

The use of an actinometer in such work is almost impossible because of the time required for the exposure of the actinometer paper, but the "Lumeter," which enables a measurement to be taken in a few seconds, would probably save many plates. In black and white work, again, where what is required is the maximum exposure which can be given without producing any deposit in the parts of the plate representing the blacks in the original all that would be required to render the calculation of the exposure absolutely mechanical would be to find out what exposure to one foot candle for a given plate and stop would just fail to produce an impression upon the plate, and then make a measurement of the light reflected from the blacks of each subject.

In enlarging, also, a measurement of the light falling upon the enlarging easel through the densest parts of the negative should, after one or two preliminary trials, enable the correct exposure to be calculated with considerable ease.

A HYDROSTATIC APPARATUS ILLUSTRATING THE LAW OF DEVELOPMENT.—The development of a photographic plate proceeds according to the equation which represents what in chemistry is called a mono-molecular reaction of the first order, although development is, of course, a heterogeneous reaction, of which the surface of the silver bromide is the variable. The law of development is very simple, and is, that the rate of development at any time is equal to a constant to the difference between the ultimate density that can be obtained if the development be indefinitely prolonged and that which already exists, that is: Rate = Constant ($D_\infty - D$).

In order to make this plain a little piece of apparatus can be made which supplies an almost perfect analogy. It consists

of a glass cylinder, to the bottom of which is attached a piece of glass capillary tubing, and then a piece of thin glass tubing, bent so as to be vertical like the cylinder (Figure 1).

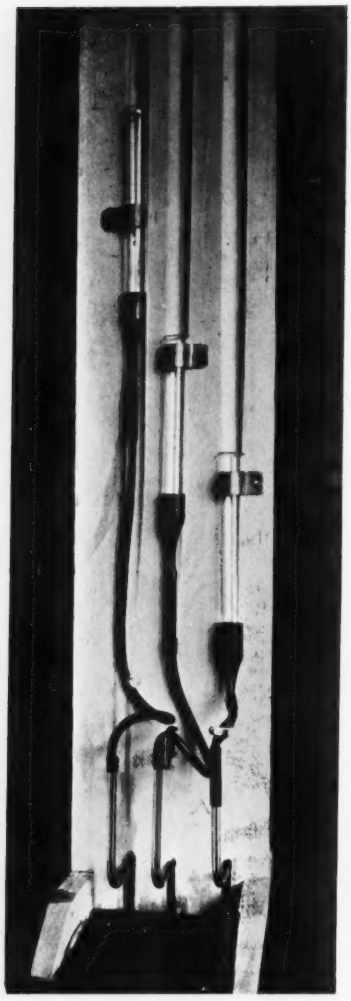

FIGURE 3.

A coloured solution is put into the cylinder, and then by turning on the tap it passes through the capillary and rises in the vertical tube until the level is the same as that of the liquid in the cylinder. The rate of rise in the vertical tube is rapid at first, and then becomes slower and slower until the level is attained.

A measurement of the time taken to rise one centimetre, when the difference between the level in the tube and that in the cylinder was twelve centimetres, gave fifteen seconds. When the difference of level was six centimetres the time was thirty seconds, and when the difference of level was three centimetres the time taken was sixty seconds; so that if H is the height in the cylinder, and h the height in the tube:

Rate of rise is proportional to $H-h$,

or: Rate $=$ Constant $(H-h)$.

We see that for this apparatus H exactly corresponds with D_∞, the ultimate density of a plate, and h corresponds with D, the density already attained.

Just as the constant for the glass apparatus depends on the size of the capillary, so the constant for development depends on the rate of penetration of the developer and the products of the reaction through the film, or the diffusion.

In general, however, when we deal with the development of a plate, we have to deal, not with one exposure, but with many different degrees of exposure received on different parts of the plates and giving rise to different ultimate densities in these parts.

In order to see the effect of this we may construct another simple apparatus (Figure 2) consisting essentially of three separate apparatuses similar to that described above, three identical tubes being arranged in front and connecting by means of identical capillary tubes with three cylinders at the back but, these cylinders are arranged so that the heights are variable, and three different heights, H1, H2 and H3, are given to the three tubes. Now if we start this apparatus we shall find that h2 rises faster than h1, and h3 faster than h2. In fact, while at first the levels in all three tubes were equal, after they have risen the levels are very different, the level of h2 being above that of h1, and h3 higher still. Figure 3 shows the apparatus after the levels have risen.

Transferring this to a plate with three different exposures capable of giving ultimate densities D1, D2 and D3, we see that it will mean that while at first they are all equal, as development proceeds the contrast between d1, d2 and d3 will increase until finally an ultimate contrast will be reached, dependent on the value of D3.

In order to measure the contrast between the levels in our three tubes the most obvious thing to do is to draw a line through the three points. The *slope* of this line will then be a measure of the contrast, and clearly the rate of increase of slope will be proportional to the difference between the ultimate steepness attainable and the steepness already attained.

PHYSICS.

By A. C. G. EGERTON, B.Sc.

RAYS OF POSITIVE ELECTRICITY.—Professor Sir J. J. Thomson gave a lecture on a "New Method of Chemical Analysis," on Friday, 7th April, at the Royal Institution.

If an electric discharge is passed through a large vacuum tube whose cathode is a tube of fine bore, positively charged particles stream back from the cathode moving in the opposite direction to the cathode rays. Sir J. J. Thomson has made a thorough investigation of these rays, which were called by Goldstein, their discoverer, "Kanalstrahlen." The apparatus employed to study these rays, consists essentially of two glass vessels connected by a narrow tube; the cathode is a fine bore metal tube provided with an ebonite plug which fits the tube connecting the two vessels. The one vessel is the discharge tube, the other the observation tube; the anode is situated at the side of the discharge tube. The discharge tube is made very large, so that a high potential discharge can be passed through the tube at very low gas pressures without danger of puncturing the glass tube. Cathode rays stream away from the cathode into the discharge tube. "Kanalstrahlen" stream through the fine tube, which constitutes a portion of the cathode, back into the observation vessel. Here they have to pass through a powerful magnetic field and electric field, so arranged that the magnetic field deflects them vertically, and the electric field horizontally. They impinge after undergoing this deflection on to a photographic plate or a willemite screen; the former is affected by the rays and registers their position and intensity, the latter by the phosphorescence set up gives a visible impression of their deflection.

The deflection of the rays is such that they may be divided into two classes—primary and secondary rays. The primary rays give short parabolic arcs having their heads in the same vertical line, which shows that the minimum electrostatic deflection undergone by the particles is the same whatever the nature of the gas. This means that the maximum potential difference through which the particles have fallen is the same, or that they take their origin close to the cathode. The secondary rays are produced by the primary rays in their passage through the gas in the observation tube, and their position of formation can be found by altering the distance through which the primary rays are under the influence of the magnetic and electric fields. Sir J. J. Thomson has found in this way that the secondary rays are due to dissociation of systems in the undeflected Kanalstrahlen, due to collision with negatively electrified corpuscles, giving rise to a negatively electrified and a positively electrified portion. The reverse can also take place within certain velocity limits, namely the collision of a positive ray with a negative corpuscle and consequent production of an uncharged particle. The study of the shape of the curves produced by the action of the particles on the photographic plate shows that either of these two actions may occur.

Sir J. J. Thomson, in his lecture at the Royal Institution, pointed out how the results of this investigation may be applied to develop a new method of chemical analysis, which is applicable to minute quantities of vaporisable substances, and which, without the necessity of using pure materials, will give directly the atomic weights of the substances under investigation. For the relative positions of the ends of the small parabolic arcs due to the primary rays are proportional

to the masses of the particles constituting the rays. Furthermore, the velocity of the rays is so great that the production of particles not completely stable under ordinary circumstances are enregistered on the plate.

Professor Sir J. J. Thomson has been able to obtain evidence of the momentary existence of CH_1, CH_2, and CH_3. Furthermore one gas does not necessarily give rise to only one type of ray, but one parabolic arc may be due to the atom with two positive charges ($^{++}_{O}$), another to the atom with a negative charge ($^{-}_{O}$) or a positive charge ($^{+}_{O}$), another to the molecule ($^{+}_{O_2}$), another to a more complicated molecule ($^{+}_{O_3}$), or more complicated still ($^{++}_{O_6}$). It appears that a negatively charged molecule is not obtainable easily, because in the molecule the electrons are more firmly bound and held together by their mutual influence, whereas in the atom they are freer; consequently, when a collision occurs with a negative corpuscle, the latter may attach itself to the atom but not so easily to the molecule. Sir Joseph Thomson illustrated this point in his lecture by recourse to a simple experiment with magnets. Compass needles were balanced on points on a card, suspended from the roof, which hung close to a magnet. When the compass needles were free to move, the whole card was attracted by the magnet: when the compass needles were removed and laid at random on the card, the latter was not attracted to the same extent.

This new method of analysis, by means of high vacuum discharges, will be excessively valuable in investigating the charges which more complicated atoms undergo and will no doubt lead to many new discoveries and unlock the secrets of the atom. Strange lines appear in these spectra (*e.g.* 65 possible $^{+++}_{Hg}$) which are not readily explainable.

ACTIVE NITROGEN.—Professor R. J. Strutt delivered the Bakerian Lecture on April 6th to the Royal Society. The subject of his lecture was the afterglow from the passage of the electric discharge through nitrogen. We mentioned it in the Physics Notes for February. If pure nitrogen be passed through a discharge tube continuously at a low pressure by suction with a Grede pump, on leaving the discharge tube, it glows with a yellow light and is highly active. It combines with iodine causing the latter to glow brilliant blue, gives a compound with phosphorus—that which is no doubt produced during the exhaustion of Sir Oliver Lodge's high tension valves by means of phosphorus—and causes the metals, when warmed sufficiently to give off vapour, to emit light giving their characteristic line spectra. Professor Strutt illustrated this point in a most beautiful manner by showing the green glow emitted by a small piece of thallium placed in the tube through which the active nitrogen passed. Professor Strutt considers the nitrogen to be in the atomic form.

SEISMOLOGY.

By CHARLES DAVISON, Sc.D., F.G.S.

THE RECENT ERUPTION OF TAAL VOLCANO IN THE PHILIPPINE ISLANDS.—In the island of Luzon, nearly forty miles south of Manila, lies lake Bombon. Near the centre of this lake, from Volcano Island, there rises Taal Volcano, which, by its eruption last January 30th, caused so much damage to the surrounding villages. The crater walls vary in height. At no point are they lower than four hundred and ninety-two feet, at the highest they rise to nine hundred and ninety-six feet.

When the United States Government took over the Philippine Islands at the close of the last century, they acquired the services of a Jesuit priest, the Rev. M. Saderra Masó, who for many years had studied and published valuable reports on the earthquakes and volcanoes of that unstable group of islands. Being appointed an assistant-director of the U.S. Weather Bureau, Father Saderra Masó has continued his useful work, one of the latest results of which is the investigation of the recent eruption of Taal Volcano. Of his interesting report on this eruption a summary is given in the present note.

During the night of January 27th–28th, the volcano issued the first warnings of the coming eruption. Instead of the usual clouds of white steam, great puffs of black smoke were emitted from the main crater, accompanied by rumbling sounds and tremors. On January 28th and 29th, explosions and earthquakes became more frequent and stronger, until at about 2.20 a.m., on January 30th, they culminated in a tremendous explosion, the sound of which is said to have been heard at a distance of two hundred and fifty miles. A huge black cloud rose from

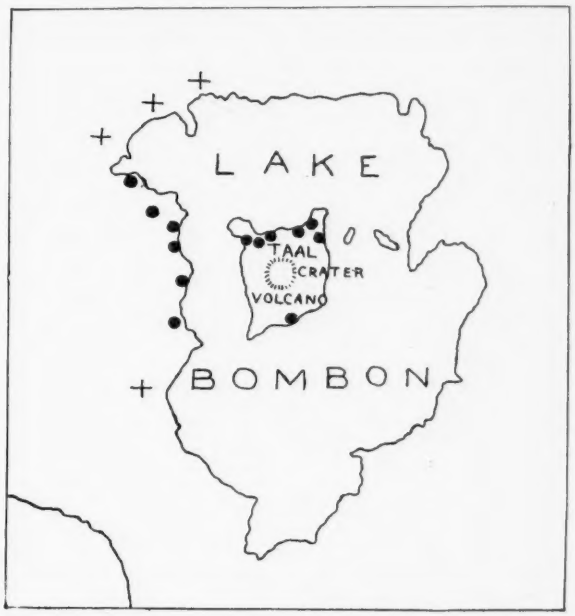

FIGURE 1.

the crater, lit up by flashes of lightning, vivid sparks and bursting globes of fire. A heavy fall of boiling mud followed the explosion, and destroyed all the vegetation and the flimsy houses on Volcano Island and along the western and north-western shores of the lake to a distance of ten miles from the crater, and caused the death of between one thousand two hundred and fifty and one thousand three hundred of their inhabitants. On the accompanying sketch-map, reproduced from Father Saderra Masó's report, the black dots indicate the towns and villages that were obliterated, and the small crosses those that were damaged.

After the eruption, there was a rush of air towards the volcano, which was noticeable for many miles around. Barometers registered a rapid fall of atmospheric pressure, which at Batangas (seventeen miles from the volcano) amounted to about one-twelfth of an inch, and at Manila (thirty-nine miles) to one-twenty-fifth of an inch.

The distribution of the volcanic mud was governed by the direction of the prevailing wind, which was from the south-east. On Volcano Island and the western and north-western shores of the lake, the mud formed a layer from two to three feet in thickness. With increasing distance, its thickness gradually diminished, until beyond a distance of fifteen miles only grey gritty dust was deposited. The finer dust was, of course, carried still farther, and, on the morning after the eruption, some fell at Manila. On the south-eastern shore of the lake no mud was to be seen, and only a little was deposited on the eastern and north-eastern shores.

After the great eruption of January 30th, no other outburst of any importance took place, and the earthquake-shocks soon diminished both in frequency and strength until they practically ceased on February 7th.

Along the shores of the lake, the damage was increased by

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the waves produced in the lake, which reached a height of ten feet. Here and farther inland, some injury was caused by earthquakes, more by the continual shaking than by the actual strength of any shock, for none of them attained a destructive degree of intensity. At the observatory of Manila, nearly one thousand shocks were recorded between the evening of January 27th and February 7th, none of which in that city reached an intensity greater than the fourth degree of the Rossi-Forel scale of intensity. In other words, the strongest were capable of making doors, windows, fireirons, etc., rattle; they produced a trembling sensation like that felt on a station platform when an express train passes. Other shocks, of the third degree, were just sufficiently strong to be felt by human beings. The great majority of the shocks were of the second and first degrees of intensity; they were microseismic movements requiring rather delicate instruments for their detection. The following table, founded on that given in Father Saderra Masó's report, shows the number of shocks of each degree registered at Manila from 11.6 p.m. on January 27th to February 7th.

	Intensity (Rossi-Forel Scale).			
	4	3	2	1
January 27 ...	...	2	3	21
,, 28 ...	10	21	31	135
,, 29 ...	9	9	28	67
,, 30 ...	8	10	16	62
,, 31 ...	16	16	28	139
February 1 ...	12	11	18	89
,, 2 ...	4	3	9	61
,, 3 ...	...	2	7	46
,, 4 ...	2	2	3	32
,, 5 ...	1	...	3	23
,, 6 ...	...	...	1	14
,, 7 ...	...	1	...	11

It will be noticed that the shocks were most frequent on the day following the beginning of the eruption and on that after the great explosion. As this occurred at 2.20 a.m. on January 30th, it is evident that the explosion caused a temporary relief of the internal strains, such as might well give rise to the old view according to which volcanic eruptions were the safety-valves that shielded us from earthquakes.

ZOOLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A.

BIRD-MARKING. — The Aberdeen University Bird-Migration Inquiry, of which Mr. A. Landsborough Thomson is the Secretary, aims at collecting more definite information on the subject of the Migration of Birds by means of the method of placing rings on the feet of a large number of birds in the hope of hearing of the subsequent movements of some proportion of them. To this end the rings are inscribed with the address "Aberdeen University," and a number (or number and letter combination) different in each case. The rings are placed on young birds found in the nest, or on any old ones that can be captured without injury. The rings are of aluminium and extremely light, and do not inconvenience the birds in any way. The marking work is chiefly carried on in Scotland, notably in Aberdeenshire, but is not confined thereto. The Inquiry has the support of Mr. J. A. Harvie-Brown, Mr. Wm. Eagle Clarke, Mr. Wm. Evans, and other well-known Scottish ornithologists, and similar Inquiries exist in England and abroad.

The coöperation of all who take any interest in Natural History questions is earnestly solicited in order to secure the best results:—

1. It is particularly requested that all who may shoot, capture, or kill, or even hear of any of our marked birds should let us know of the occurrence. As accurate particulars of date and locality as possible are desired, but, above all, the number (or number and letters) on the ring. Indeed, except where it has been possible to reliberate the bird uninjured, the ring itself should always be sent; or the ring and foot, or even the whole bird. We always refund postage if asked to do so.

2. Coöperation is invited in the actual work of marking, of any who are specially interested, and have some knowledge of birds, and also time and opportunity for the work. The necessary rings, schedules, and postage stamps, are supplied by us without charge, and we undertake to let the marker know of each case of a bird marked by him being recovered, and to let him have copies of printed reports so far as possible.

The following results obtained at an early stage of the work will serve to indicate what is to be expected from it; these are merely a few records which happen to be of considerable individual interest:—

A Widgeon duckling (*Mareca penelope*), one of five marked in June, 1909, on Loch Brora, Sutherland, Scotland, was taken in a duck-decoy in Province Groningen, north-eastern Holland, on 3rd September, 1909. This bird was thus only three months old when it was found more than 500 miles from its birth-place. A second member of the brood was shot on the Trent, near Retford, Lincolnshire, England, in January, 1911, having worn the ring for a year and a half.

An adult Swallow (*Hirundo rustica*) caught and marked at a farm near Tunbridge Wells, Kent, England, in June, 1909, was re-caught at the same farm in June, 1910.

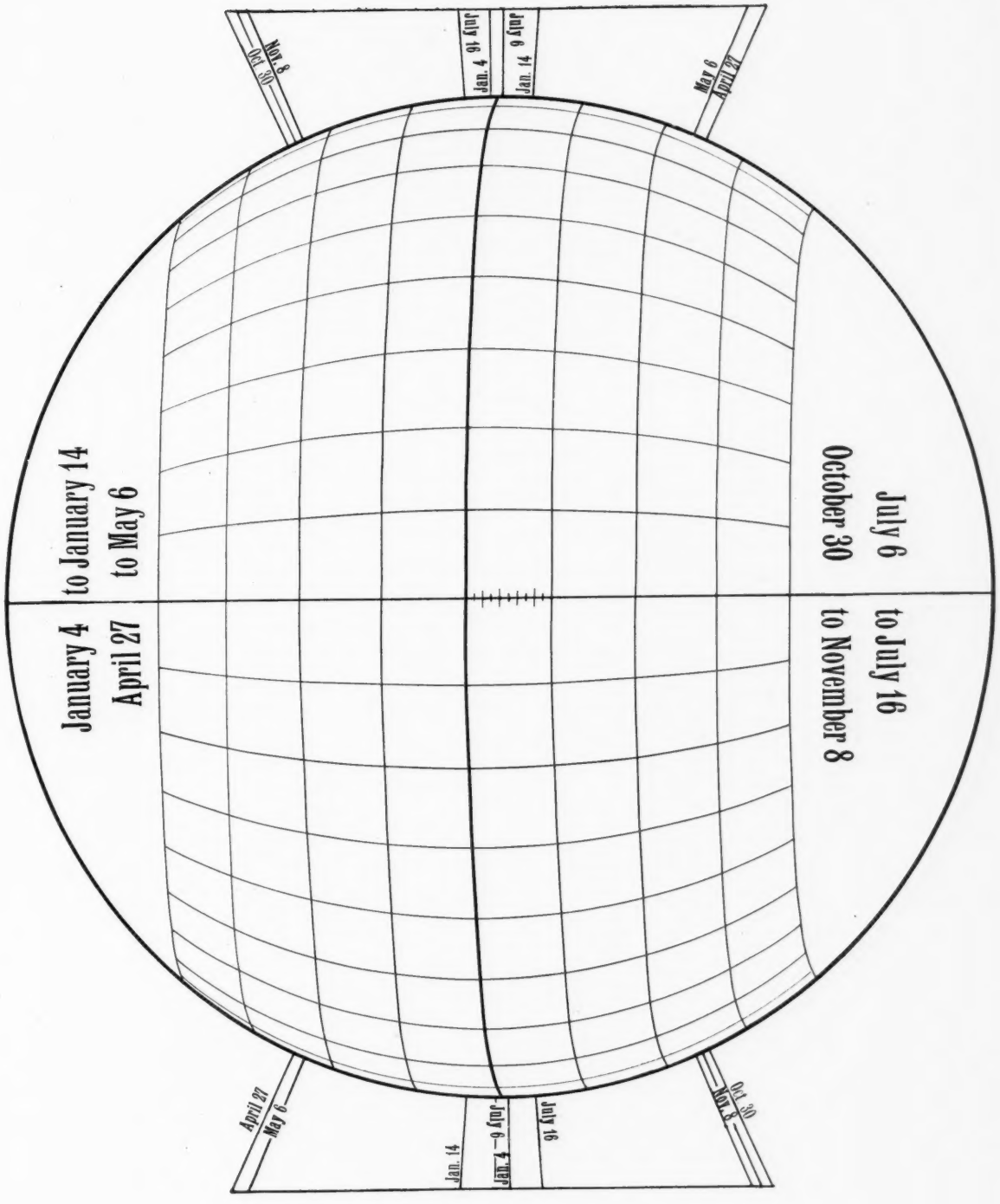
Five Lapwings (*Vanellus vulgaris*) marked as chicks in the North-east of Scotland, in the summer of 1910, were shot respectively in Counties Tipperary, Roscommon, Cork, and Limerick, Ireland, and in Southern Portugal, during the winter 1910–11.

A Song-Thrush (*Turdus musicus*), one of a brood marked as chicks in the nest at Skene, Aberdeenshire, in early June, 1910, was shot near Leiria, Portugal, in early November of the same year. The localities are about one thousand two hundred and fifty miles apart.

DISCS FOR SOLAR PROJECTION.

By JOHN McHARG, M.A.

IN the series of maps for solar projection of which an example is printed on the following page, the graduation to intervals of 10° in latitude and longitude is only carried to the fortieth parallel of latitude. For convenience in estimating the diameters of sunspots, a portion of the central meridian is divided into degrees, one of which is equal to seven thousand five hundred and fifty-four miles. The heliographical latitude of the centre and the position-angle of the solar axis are considered positive, the former when the North Pole is tilted toward the observer, and the latter when it is inclined from the north point toward the east; this happens on the dates when the directing lines at the right-hand side of the map are above the equator. It will be observed that with the exception of a brief period about the time of the solstices, the above quantities have the same sign throughout the rest of the year. The solar image, when projected on the disc by a refractor provided with an astronomical eyepiece, suffers reversal from left to right, after the fashion of images in a plane mirror or that of the sun in a diagonal. The correct position-angle of the disc may be easily obtained by stretching a hair tightly across the field of the eyepiece a little beyond its focal plane. This is then turned till the image of a spot runs along the hair, or in its absence by depressing the image till a mere thread of light remains above the crosswire. The coincidence of equators of image and disc is then secured by causing the appropriate directing line on the disc for the date to coincide with the image of the crosswire, intermediate positions to those given being supplied by estimation or measurement.



V. Latitude2of Centre ± 4°.

REVIEWS.

AËRONAUTICS.

Elementary Aëronautics.—By A. P. THURSTON. 126 pages. 126 illustrations. 8½-in. × 5½-in.

(Whittaker & Co. Price 3/6.)

Anything from the pen of Mr. Thurston, the able associate of Sir Hiram Maxim in his later experimental work, must of necessity be of interest, and the book having the above title bears this out. The book abounds with up-to-date experimental results and diagrams relative to curved surfaces. Although a few of them are chiefly of academic interest most are of a highly practical value.

Another interesting feature is the large number of reproductions from photographs of artificial stream lines formed from cloud vapour of ammonium chloride. The author introduces some new work on stability although he would appear to have overlooked one important aspect of the problem. We all thank Mr. Thurston, and congratulate him on giving us this book.

T. W. K. C.

The Theory and Practice of Model Aëroplaning.—By V. E. JOHNSON, M.A. 148 pages. 61 illustrations. 7¾-in. × 5-in.

(E. & F. N. Spon. Price 3/6 net.)

There is nothing but praise to dispose upon this little book. The author has modestly dedicated it to those interested in the minor branch of model aëroplaning, but there is no student in any branch of aëronautical engineering who will not learn something from this book. From end to end it is full of reliable information. Great pains have been exercised to exclude not only misleading but doubtful matter, and there is a complete absence of all "padding."

Although written in simple language and without a mass of mathematical formulae, it is yet the most truly scientific work on model aëroplaning that has yet appeared, and one that all taking interest in this subject must obtain.

T. W. K. C.

Principles of Aëroplane Construction.—By RANKIN KENNEDY, C.E. 137 pages. 50 illustrations. 8½-in. × 5½-in.

(J. & A. Churchill. Price 5/- net.)

A considerable amount of this book might with advantage have been omitted, being based on a somewhat doubtful mass of mathematical work and out of date methods.

This criticism does not apply throughout, for in the second half the author discusses the propeller and especially the Hélicoptère in a very lucid manner, disposing of some of the fallacies concerning the latter, with some well-timed remarks. On the whole this book, I think, might be described as "not sufficiently up to date."

T. W. K. C.

How to Build an Aëroplane. 2nd edition. By ROBERT PETIT. 118 pages. 93 illustrations. 8½-in. × 5½-in.

(Williams & Norgate. Price 2/6 net.)

This book has reached its second edition. The translators have taken the opportunity to correct several errors which crept into the first edition and it now forms a very concise little book dealing with aëronautical design. Considered from the point of view of the "builder," for whom the title would suggest that this book was principally intended, it still leaves much to be desired, hardly half-a-dozen pages being devoted to constructive detail. On page 84 the author rightly alludes to the fine construction of the *Antoinette Monoplanes* but refers to the figure on the opposite page which is of a *Wright Biplane*, the very antithesis of construction. We had hoped to see this error in the first edition corrected in the second. Perhaps the translators will see to this in the next edition. In other respects they have done their work very well indeed.

The book is written in plain language, clearly printed on good paper, and sold at a popular price. It will, we are sure, be widely read.

T. W. K. C.

"*Birdflight as the Basis of Aviation.*"—By OTTO LILIENTHAL. With a biographical introduction and addendum by GUSTAVE LILIENTHAL. Translated from the second edition by A. W. ISENTHAL, A.M.I.E., F.R.P.S. With a portrait. 142 pages. 94 illustrations, and 8 litho plates. 9½-in. × 6½-in.

(Longmans, Green & Co. Price 9/- net.)

At the present time, when so much interest is taken in Aviation, the publication of a second edition of Lilienthal's well-known book on "Birdflight" is very appropriate. The translator claims, we think with justice, that Lilienthal was the Father of gliding experiments. He is almost the Father of the aëroplane, since it is quite evident that the experiments upon gliding led to the practical development of the aëroplane. We believe we are correct in saying that it was in experimenting with a power-driven glider that Lilienthal, unfortunately, lost his life. The translator has done his work very well. It is difficult to find any of those slips in translation that are sometimes only too much in evidence, particularly when the original is in German. The idioms in German and French are often very difficult indeed to give the English equivalent of; and the translator too often gives a literal interpretation, which is oftentimes almost nonsense. In the present instance, the translator understands his subject thoroughly; he is an enthusiast also, and we believe he has given us what the master wrote.

The appearance of Lilienthal's book also, is of peculiar interest just now, when the Ornithopter, which should be a direct copy of bird wings, and so on, has so far not been able to obtain even a very small footing in the aviation world. The practical construction of Ornithopters has been announced, and the usual claims made for them, which according to Lilienthal's investigations should be maintained; but they appear to get no farther. Lilienthal made a very careful study of birds at first hand; and the book before us is full of very useful information, indeed, upon the mechanism of birds' wings, how the bird uses them; and in particular, the action of the wings of sea birds. He appears to have made a very exhaustive study, not only of the birds that we find flying over our fields, but also of those sea birds—the albatross, the sea gull, the stormy petrel, and others—whose flight is apparently so different to that of the land birds. Sea birds are able to rise vertically from the ground, according to Lilienthal, and to maintain flight against the wind, without any exertion whatever. He evidently looked forward to the day when man would be able to do the same. It is, perhaps, interesting to note that the development of the aëroplane, so far from being in the direction of reduced power, is going headlong to the opposite extreme. The early aëroplanes were equipped with engines of 25 H.P.; those a little later at 35 H.P., and the figure has steadily increased, till the machines which have done the best work in a certain sense, during the last few months, have been equipped in

engines of 100 H.P.; and aviators and engineers who are catering for aviators' wants are scheming to produce engines of larger and larger horse-power. Aviators are impressed with the well-known law, that the pressure supporting any given surface varies directly as the square of the velocity of the machine through the air, or what amounts to the same thing, of the air past the machine. Unfortunately, there is another law, viz., that the power required varies as the cube of the velocity. Lilienthal believed in reducing the power, and we believe that a careful study of the experiments he made, and of the laws which he worked out, will lead to a reduction of power, and to a real advance in aëroplanes, on the lines upon which he worked.

Inventors of aëroplanes appear to have availed themselves to a considerable extent of the facts which his experiments brought out, but to have parted company with him at a certain point. Possibly in a little while the course may be reversed.

We heartily recommend the book to anyone who wishes to get a sound knowledge of the principles of bird flight, and of the classical experiments that Lilienthal made.

S. F. W.

ASTRONOMY.

Annuaires Astronomiques pour 1911 et 1912 de l'Observatoire Royal de Belgique publié par les soins de G. LECOINTE. Directeur Scientifique du Service Astronomique. 1911—299 pages; 1912—467 pages (7-in. × 5-in.)

These well-known Annuaires, which have been published each year since 1834 without interruption, give in an accessible form practically all the astronomical data required by amateur astronomers together with considerable meteorological and magnetic data often required by practical astronomers.

There is no work in English which corresponds to these Annuaires, but most astronomers have felt the need of such handbooks which give in a concise form, without the academical detail of the Nautical Almanac, the chief observable phenomena.

Each edition contains a useful map of the world illustrating the time zones and showing which countries have adopted the standard time system.

The Annuaire for 1912 is specially interesting as it summarizes the observations made upon Halley's comet from the date of its re-discovery in 1910 and four plates illustrate the comet's changes during the period it was under observation. A further plate shows a star chart with the path of the comet at the time of inferior conjunction and now that the elements of the comet are so well known it may be possible to at least trace the comet photographically through a much longer period than has ever been done before.

The Annuaires are fairly comprehensive and explanatory and can be recommended as a useful "companion" to practical observers.

W. S.

William Thomson—Lord Kelvin.—By DAVID WILSON. 56 pages. 8½-in. × 5½-in.

(Glasgow: John Smith & Son. Price 2/- net, cloth; 1/- net, paper.)

Reviewing books would be a very pleasant pastime, if they were all so fascinating as this one. It is thoroughly enjoyable—delightfully original. Much sound philosophy and a true glimpse of a great man of true scientific spirit is included in fifty-six pages of real literature abounding with amusement. Read how Lord Kelvin was the "righteous soul in harmony with things in general." There is a chapter which ends "failing to realise the deep and irresistible power of capillary (and other) attractions"! There is no doubt as to the deep attractiveness of the book.

A. C. E.

BOTANY.

(1) *The Liverworts, British and Foreign.*—By SIR EDWARD FRY. 74 pages. 47 illustrations. 7½-in × 5-in.

(Witherby & Company. Price 1/6 net.)

(2) *Mosses and Liverworts.*—By T. H. RUSSELL. 211 pages. 10 plates. 8½-in. × 5½-in.

(Sampson Low & Company. Price 4/6 net.)

These two books are alike in many respects. Both attempt to deal in a more or less "popular" style with a remarkable group of plants, which has, by many botanists, been regarded as occupying a central position in the vegetable kingdom, and forming a transition from the green algae on one hand and the great fern and flowering plant alliance of the vascular plants on the other. This group, the bryophyta, has, until recently, been divided by general consent into two classes—the Liverworts and the Mosses—though there are signs that this twofold division is breaking up and will be replaced by a more scientific system of classification based upon the results of recent work on the morphology and development of these interesting plants.

(1) Sir Edward Fry's little book is chiefly a mixture of borrowings from ancient and modern authors, and cannot be said to present anything like an accurate view of the structure, biology, classification and relationships of the Liverworts. The extremely small portions of the book that appear to be based upon the author's own studies are chiefly remarkable for eccentric spellings, such as "antherizoids" and "amphigastra," strange interpretations of the functions of wrongly described structures, and some of the worst drawings in a badly-illustrated book.

However, it is just possible that some amateur naturalists into whose hands this book may fall will find in it something to stimulate curiosity concerning the much-neglected Liverworts, and to impel them to obtain a more reliable guide to the study of these plants. For the structure and development of these plants, it is quite evident that we have as yet no "popular" work that can be recommended to the general reader, though the botanical student will find practically all he requires in the works of Campbell and Goebel. It is only fair to mention that Sir E. Fry gives the names of these works in the last few pages of his little book. As little books of this kind appear to find a sale, we must admit that with all their faults they may serve a useful purpose.

(2) Mr. Russell's more comprehensive and ambitious work has quickly passed into a second edition—a fact which testifies rather to the growth of interest in the Mosses and Liverworts than to the merits of this particular book. Certainly this book will aid the beginner to recognise some of the commoner British species belonging to these groups, though the author is obviously much less familiar with the Liverworts than with the Mosses. The book is written in a bright and interesting style, and the author has wisely refrained from much generalisation and discussion on the morphology, biology, and classification of these plants. Some of the illustrations are fairly good, but perhaps the best feature of the book is the chapter of nearly forty pages on the collection and preservation (including microscopic mounting) of specimens.

It may appear somewhat harsh to criticise adversely such books as Sir E. Fry's and Mr. Russell's, since the avowed object of the author in each case is merely that of arousing interest in the plants dealt with and pointing the way to more advanced and systematic study with the aid of larger works. If the writers of such books would simply confine themselves to what they are more or less familiar with—the general characters of the commoner species and their habitats, and methods of collection and preservation—they would entirely disarm the criticism which, as it is, they provoke by their ill-informed and totally unnecessary treatment of the scientific aspects of the subject. If it is considered necessary to touch upon these topics, it would be much better to give a series of

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quotations from reliable books or papers by scientific writers, or to invite the coöperation of a scientific naturalist—or at the very least to submit their manuscript to an expert for revision. If either of these courses were adopted, something might be done to remedy the slipshod and inaccurate character of "popular" books on Botany and Nature Study. F.C.

CHEMISTRY.

Bacteriological and Enzyme Chemistry.—By G. J. FOWLER, D.Sc., F.I.C. 328 pages. 32 illustrations. 7¼-in. × 5-in.

(Edward Arnold. Price 7/6 net.)

Just as the border line between physics and chemistry is rapidly breaking down, so, too, in another direction, is the division that formerly separated chemistry from biology. Not only has chemistry made clear many previously obscure physiological processes, but the principles of the new branch of the science have found technical applications in many directions. In fact, so important has biological chemistry now become that the Institute of Chemistry has established a special examination in the subject, and one of the objects with which this book was written was to provide a general introduction to the numerous books which must be studied by those reading for this examination. For this purpose the book will be found admirably suited, and, in addition to this, it is so simply and clearly written that it may be read with interest by the general reader.

After a good description of the characteristics of chemical action in living bodies, and the methods used in bacteriological work, it gives a clear outline of the principles of organic chemistry; and this is followed by an account of the specific actions of various enzymes and bacteria, together with a description of their application in various industrial processes, such as the fermentation of indigo, the purification of sewage, and in agriculture.

It is to be regretted that while in some of these descriptions the author has availed himself of the scientific assistance of specialists in different branches, he has neglected to do so in others, the result being that his accounts of technical processes are of very unequal value. Thus, some of his statements about the manufacture of vinegar are inaccurate, and others only partially true, while the process described as that in general use is one that has been obsolete for very many years.

It is stated (page 149) that, according to Pasteur, the oxidation of the completed acetic acid to carbon dioxide and water is effected by other organisms, such as yeasts, and so on. Now, it is a fact that the acetic bacteria themselves oxidise the acetic acid as soon as they have exhausted the alcohol; and a reference to the original treatise of Pasteur shows that he wrote the very opposite to what is stated by the author, viz.—"When vinegar loses its acidity this is solely due to a slow combustion process which is brought about by *Mycoderma aceti*."

Another inaccuracy occurs in the description of the fat-splitting enzymes, where it is stated that mutton and beef fats are compounds of glycerine and stearic acid. Both of these substances are undoubtedly present in the fats, but the commercial beef "stearine" is far from agreeing in composition with the chemical compound "stearin," for it contains palmitic, oleic and other fatty acids—in some cases in greater proportion than stearic acid.

But these errors are trifling in comparison with the general excellence of the book, and the author may be congratulated upon having maintained interest in his subject without sacrifice of its scientific value. C. A. M.

Alchemy: Ancient and Modern.—By H. STANLEY REDGROVE, B.Sc. (Lond). 141 pages. 16 illustrations. 8¾-in. × 5½-in.

(William Rider & Son. Price 4/6 net.)

Most of the modern books upon Alchemy suffer from the drawback of having been written without due appreciation of the scientific basis underlying many of the old theories, or, on the other hand, with an exaggerated importance attached to what was obviously meant as mystical symbolism.

The author of the present book, however, is not only a man of scientific attainments, but is, as his writing shows, strongly in sympathy with the mystical trend of the alchemists, and the result is an exceedingly interesting study of their doctrines.

In no other book with which we are acquainted is the striking manner in which modern chemical thought tends to approximate the philosophical views of the alchemist so clearly brought out. As the author shows, the alchemists first formed their theories, and then tried to find for them experimental support, whereas in modern chemistry experimental investigation has gradually led to the formulation of theories, which, on the physical side, are little distinguishable from those of alchemy. Thus the notion of one primordial form of matter, upon which was based the alchemists' hopes of transforming baser metals into gold, has been rendered more than probable by recent researches in radio-activity. In the earlier part of the book, a good outline is given of the views of the alchemists upon matter and their mystical application to the moral world, and this is followed by brief historical sketches of the leading alchemists, which are well illustrated by reproductions of old engravings. It was perhaps inevitable, that this biographical part of the book should lack the interest of the philosophical portion. The last chapter, in which are contrasted the ancient and modern views upon the transformation of the elements, is particularly interesting.

The author's general attitude towards the question of the transformation of metals into gold in the past, is that of the agnostic, but most readers will be inclined to think that his agnosticism leans to the side of credulity in attaching much weight to the testimony of Helvetius. C. A. M.

PHYSICS.

The Gyroscope.—By V. E. JOHNSON, M.A. 52 pages. 24 illustrations. 7¼-in. × 5-in.

(E. & F. Spon. Price 1/6 net.)

The book is an experimental guide to the interesting phenomena connected with gyroscopes. It gives instruction how to make gyroscopes and experiment on them to the best advantage, in order to show their properties. It leads up to the construction of a mono-rail car, balanced by one or two gyroscopes. The author has left theory alone, wisely in a short book of this kind. But those who wish to know something of the phenomena connected with rotating masses, will do well to execute some of the experiments described; while others no doubt would be much interested by merely carrying out the experiments as a pastime. An explanation on page 43 would be improved by substituting "and" for "in the latter": as it stands the explanation appears incorrect. A. C. E.

An Elementary Text-book of Physics. General Physics.—By R. W. STEWART, D.Sc. 414 pages. 187 illustrations. 7½-in. × 5-in.

(Charles Griffin & Co. Price 4/6 net.)

Dr. Stewart's text-books are the essence of clearness and lucidity of explanation. This is the first volume of the series of Physical Text-books, and deals with physical measurements, dynamics, statics, hydrostatics and the properties of matter. The text-book contains just the necessary amount of detail to give the student a thorough grounding in the subject. Chapters as, for example, that on the balance, or that on the determination of density, are exceptionally clear on subjects that many elementary text-books skimp over.

The general arrangement of the book is very excellent. The student indulges in units and measurements of the fundamental units till Chapter V., then velocity, acceleration, and circular motion are dealt with. It is pleasing to find the latter subject treated in its proper place and with due regard to its practical importance. Succeeding chapters deal with force, work and energy in a very clear manner. Then comes statics,

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with a chapter on the balance, followed by hydrostatics, properties of matter, determination of densities, and finally the main properties of matter in the gaseous state. The book ends with a valuable up-to-date chapter on pumps.

A. C. E.

Physical Measurements.—By A. W. DUFF and A. W. EWELL. 258 pages. 78 illustrations. 8½-in. × 5½-in.

(J. & A. Churchill. Price 7/6 net.)

The book will be a great help alike to those taught and to the teacher. In the first case the book is not too long, not too minute in detail, but the descriptions are concise and to the point. In the second case the book covers a fairly wide field, so that it aids the teacher in selecting experimental studies for any particular class of students. Another valuable feature is its numerous references both to practical treatises such as Kohlrausch's "Physical Measurements," and also to smaller class text books.

In the introduction, which gives general advice as to the taking of observations, their possible and probable errors, and the plotting of curves, occurs this sentence:—"Much time in the laboratory will be wasted unless some preparation be made before coming to the laboratory . . . . this may usually be done at home in a few minutes, whereas it might require an hour or more in a laboratory where a number of people are moving around." This is very true. The man who is researching would not come to the laboratory and spend half-an-hour picking up the thread of the previous day's work; he comes generally with a fixed intention of trying some particular experiment which he has carefully planned out. So, too, it should not be that the student should have to spend much time reading through the directions for carrying out an experiment during his attendance at the laboratory, only to carry them out like a cook following a recipe. A little previous study, a preliminary lecture, and a little personal instruction, is more desirable; then the experiments will be carried out intelligently, and without the necessity of elaborate descriptions of the mode of procedure.

One would like to have seen a more complete account of the use of a cathetometer, of specific gravity measurements, and of thermometer corrections: points of which it is most desirable that a student who subsequently researches should have a practical knowledge.

A. C. E.

ORNITHOLOGY.

Britain's Birds and their Nests. By A. LANDSBOROUGH THOMSON, with an introduction by J. ARTHUR THOMSON. 340 pages. 132 plates. 10¼-in. × 7½-in.

(W. & R. Chambers, Limited. Price 21/- net.)

This book, which is illustrated by Mr. Rankine's coloured drawings, is a careful compilation of the most important and interesting details with regard to British-breeding birds, in which the writer has incorporated unpublished records of his own and of many competent observers whom he counts amongst his friends. The text is written in language which is easily understood, and the system and nomenclature adopted are those followed in the second edition of Howard Saunders' "Manual of British Birds."

As regards the colouration of the birds and the eggs, the plates will prove very useful. In some of them, however, one particular flower, which is characteristic presumably of the habitat of the bird, has been dragged into the picture and emphasised in such a way that it detracts somewhat from the intention of the drawing.

Professor Arthur Thomson contributes an introduction in which he treats birds from a biological point of view, emphasising the interest to be gained from their study, but saying that while the living bird attracts most minds, and provides a man with enough to keep him busy all his life, half the wonder will be missed if there is not also some analysis of structure. He touches on the behaviour, migration, and development and evolution, as well as the practical importance of birds, and concludes with a plea for the efforts which are being made towards bird protection, partly by legislation, partly by the education of public opinion (e.g., as regards the use of feathers in decoration, other than those from domesticated birds, like the ostrich, and from birds shot for food) and partly by the establishment of bird sanctuaries, some of which have already been attended with remarkable success; for when a bird has been exterminated, its loss is irreparable.

W.M.W.

NOTICES.

A NEW FIELD GLASS.—We have received from Messrs. C. P. Goerz's Optical Works, Limited, a list of their Trieder Binoculars, among which a new introduction, the "Neo-Trieder," calls for attention, as it has several special features, among which are its excellent definition, its increased field of view, which means, of course, that more of the field looked at is seen, while there is enhanced stereoscopic effect and greater illumination and brightness of the picture consequent upon the employment of larger object glasses.

SCIENTIFIC PHOTOGRAPHIC PLATES.—There must be many who are seeking for photographic plates for various scientific purposes, and to these we commend the descriptive list of those issued by Messrs. Wratten and Wainwright, of Croydon. A great deal of useful information is incorporated, and reference is given to special booklet which this firm has prepared, dealing with particular scientific work.

A CINEMATOGRAPHIC HAND-CAMERA. — The Aëroscope, of which details have reached us is practically a hand-camera loaded with four hundred and fifty feet of film and worked by means of a small air engine. It is brought out by the Aëroscope Company, 18, Charing Cross Road. W.C.

PRESERVATION OF THE EYE-SIGHT.—The receipt of a small booklet entitled "Eye-Sight Preserved," containing many useful hints, reminds us that Mr. Aitchison, who is responsible for it, is always ready to test eye-sight and give advice without charging any fee.

NEW APPARATUS.—Among the new instruments which Messrs. Zeiss have recently put upon the market are telescopic spectacles which have been introduced for the benefit of persons suffering from extreme myopia. Another is the cardioid ultra-microscope, devised by Dr. Siedentopf, which is adapted for the examination of colloid solutions, diluted precipitates, and the observation of micro-chemical and photo-chemical reactions. We may mention also the new oral illuminator for the use of dental surgeons and the new method of illuminating operating theatres in hospitals with a search-light and distributing mirrors.

ASTRONOMICAL LECTURE.—Mr. Frank C. Dennett informs us that he still has a few dates vacant for the delivery of his lecture on "The Sun, its Structure and Influence," illustrated by an unique set of lantern slides. Mr. Dennett's address is 6, Eleanor Road, Hackney, N.

THE BRITISH ASSOCIATION.—A preliminary programme has been issued for this year's meeting of the British Association, which, as already announced, is to take place at Portsmouth, on August 30th and following days.

The opening meeting will be held in the Town Hall on Wednesday evening, August 30th, when Sir William Ramsay, K.C.B., will assume the presidency and deliver his inaugural address. In the same hall the first evening discourse will be delivered on Friday evening, September 1st, by Dr. Leonard Hill, on "The Physiology of Submarine Work," and the second, on Monday evening, September 4th, by Professor A. C. Seward, on "Links with the past in the Plant World."

XUM

A BIRD'S-EYE VIEW OF THE HISTORY OF ASTRONOMY.

By W. ALFRED PARR.

"FOR it is my opinion that the occasions by which men have acquired a knowledge of celestial phenomena are no less admirable than the discoveries themselves." Thus wrote Kepler in memorable words at the beginning of the seventeenth century, and few will deny that the history of the oldest and grandest of the sciences possesses a fascination far transcending that of many another record of human activity. In no other sphere of knowledge is the gradual unfolding of human genius so palpably shown as in this slow endeavour throughout the centuries to unravel the mysteries of the stars, for the movement of the mind has been constantly onward, and the problems of astronomy have ever called its highest energies into requisition.

To chronicle, as concisely as may be, the salient features in the more modern aspect of this upward struggle, is the object of the following Table, which purports to present in its vertical columns a chronometrical, and in its horizontal columns a contemporary miniature history of astronomy, embracing the chief biographical, theoretical, and instrumental details of any given period. In order to bring the whole within reasonable dimensions the vertical spaces have been arranged in periods of fifty years, beginning with A.D. 1500, the epoch immediately succeeding the Revival of Science in Europe, thus the various landmarks in the evolution of modern astronomy appear in close perspective, showing, in a more graphic manner than is otherwise possible, how completely each stage in the progress of the science has depended on those that preceded, besides affording a comprehensive mental picture of this later development as a whole. The method adopted not only imparts a sense of proportion to the conception of history which can never be gained from a mere perusal of abstract dates or a study of isolated periods, but also permits of the separate study of the contained matter in a specific way, for the descending columns give a compressed history of any particular *subject*, while the horizontal columns treat of any particular *period*.

Before, however, entering upon a detailed study of the Table itself, it will be well to premise, in as brief a manner as possible, an epitomized account of the leading discoveries which were made during the whole of the pre-Copernican period.

PRIMITIVE ASTRONOMY.

Astronomy was cultivated from the earliest times in EGYPT, INDIA, and CHINA. The path of the sun and moon amongst the stars forming the ZODIAC, and the primary divisions of the year and month were determined, the motions of the five planets, MERCURY, VENUS, MARS, JUPITER, and SATURN studied, and the OBLIQUITY OF THE ECLIPTIC measured by the nations of antiquity, the most systematic astronomical observations being those of

THE CHALDEANS

who map out the CONSTELLATIONS about 2000 B.C., and who discover that the PHENOMENA OF ECLIPSES repeat themselves in the SAROS PERIOD, or cycle of eighteen years. The next great advance is made by

THE GREEKS.

B.C. 636 THALES OF MILETUS holds the earth to be a sphere, and predicts a solar eclipse. (The *Gnomon* is in use, and *Sundials* are constructed.)

„ 582 PYTHAGORAS, according to his disciple PHILOLAUS (B.C. 400), speculates upon the motion of the earth.

„ 409 EUDOXUS OF CNIDUS expresses the planetary motions by the aid of geometry, and sets up the hypothesis of *Moving Spheres*, afterwards extended by CALLIPPUS (B.C. 330).

„ 395 HERACLIDES OF PONTUS is the first to teach the doctrine of the *Earth's Diurnal Rotation*.

„ 300 ARISTILLUS AND TIMOCHARIS determine the relative positions of the principal stars of the Zodiac, thus preparing the way for HIPPARCHUS.

„ 280 ARISTARCHUS OF SAMOS is the first to propound the *Heliocentric System*. (Employment of the *Armillary Sphere*.)

„ 250 APOLLONIUS OF PERGA devises the system of *Eccentrics* and *Epicycles*.

„ 160 HIPPARCHUS, the greatest astronomer of antiquity, establishes the science on a firm footing by his catalogue of 1,080 stars, and his discovery of the *Precession of the Equinoxes*, as well as by his precise observational methods ensuring accurate results. (Employment of the *Astrolabe*).

A.D. 130 PTOLEMY OF ALEXANDRIA elaborates in his "*Almagest*" the *Epicycles* and *Deferents* of his predecessors, thus discarding the juster heliocentric views of Aristarchus. The *Ptolemaic*, or *Geocentric*, *System* is dominant for fourteen centuries.

After this time the Alexandrian school of astronomy declines until after the *Mohammedan Conquest* in 642, the next advances being made by

THE ARABS.

„ 813 ALMAMON founds a school of astronomy at *Bagdad*, and has Ptolemy's "*Almagest*" *translated* into Arabic.

„ 850 ALBATEGNIUS, the most celebrated astronomer of the Arabs, makes accurate observations, and compiles valuable *Astronomical Tables*.

„ 903 AL-SŪFI revises the Alexandrian *list of stars*.

„ 1000 ABUL WEFA discovers the *Moon's Variation*.

„ 1433 ULUGH BEGH establishes a well-equipped *Observatory* at *Samarcand*, and compiles a valuable *Star Catalogue*.

After this time Eastern astronomy comes to an end, but Western Europe continues the cultivation of the science introduced by the Arabs into Spain, the first advances being made by

THE MOORS.

„ 1038 ALHAZEN discovers the *Law of Refraction*.

„ 1080 ARZACHEL, of *Toledo*, publishes his *Toletan Tables*, and repeats the observations of Albategnius with greater accuracy.

„ 1230 The Arabic version of Ptolemy's "*Almagest*" is *translated* into Latin, and about

„ 1270 ALFONSO X. OF CASTILE produces at Toledo the *Alphonsine Tables*, compiled by the best mathematicians of the Moorish universities.

The impulse thus given to astronomy by the two latter events draws the attention of Western learning to the science, and JOHN HOLYWOOD'S (SACROBOSCO) publication of a TREATISE ON THE SPHERE about 1230, and NICOLAUS VON CUSA'S speculations on the PLANETARY SYSTEM about 1440, prepare the way for the advent of COPERNICUS.

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CHRONOMETRICAL CHART OF THE D

PERIOD.	BIOGRAPHICAL.	THEORETICAL.
A.D. **1500** (Time of— Henry VIII. Edward VI.)	COPERNICUS, 1473–1543 (Works in Polish Prussia). TYCHO BRAHÉ, 1546–1601 (Denmark and Bohemia).	The GEOCENTRIC SYSTEM of *Ptolemy*, dominant for fourteen centuries, is brought renewed prominence by *Purbach* (d. 1461) and *Regiomontanus* (d. 476), but th HELIOCENTRIC SYSTEM is definitely revived by *Copernicus* in 1543.
1550. (Mary, Elizabeth.)	GALILEO, 1564–1642 (Italy). KEPLER, 1571–1630 (Bohemia and Germany). SCHEINER, 1575–1650 (Germany).	*Tycho*, by collecting a vast mass of valuable observations, prepares the way for th theories of *Kepler*, who introduces the DYNAMIC CONCEPTION into Astronomy b his *Three Laws* of the planetary motions, which form the connecting link betwee the theories of *Copernicus* and the discoveries of *Newton*.
1600. (James 1. Charles I. Commonwealth.)	HEVELIUS, 1611–1688 (Germany). HORROX, 1619–1641 (England). HUYGENS, 1629–1695 (Holland). NEWTON, 1642–1727 (England). FLAMSTEED, 1646–1719 (England).	*Galileo*, by his telescopic discovery in 1610 of JUPITER'S SATELLITES and the PHASE OF VENUS, firmly establishes the Copernican doctrine, and lays the foundation o OBSERVATIONAL ASTRONOMY. *Scheiner*, from the observation of SUNSPOTS, discovered in 1610 by *Fabricius* an *Galileo*, determines the Sun's rotation. *Horrox* predicts on dynamical principles and is the first to observe (with *Crabtree*) a TRANSIT OF VENUS in 1639.
1650. (Charles II. James II. William III. and Mary.)	HALLEY, 1656–1741 (England). BRADLEY, 1693–1762 (England).	*Riccioli*, *Hevelius* and *Grimaldi* lay the foundation of SELENOGRAPHY by constructin lunar charts. *Huygens* discovers the true nature of SATURN'S RING in 1659. *Newton*, by the publication of the "*Principia*" in 1687, establishes the UNIFICATION OF CELESTIAL AND TERRESTRIAL SCIENCE, and shows *Kepler's Laws* to proceed from the action of GRAVITATION. *Flamsteed*, whose lunar observations aid Newton's calculations, forms the FIRST MODERN STAR CATALOGUE.
1700. (Anne, George I. George II.)	WM. HERSCHEL, 1738–1822 (England). LAPLACE, 1749–1827 (France).	*Halley* predicts on *Newtonian Principles* the RETURN of the COMET OF 1682 makes the first determination of STELLAR PROPER MOTION, and the first SOUTHERN STAR CATALOGUE. *Bradley* discovers the ABERRATION OF LIGHT and the NUTATION OF THE EARTH'S AXIS, thus laying the foundation of accurate stellar astronomy.
1750. (George III.)	BESSEL, 1784–1846 (Germany). FRAUENHOFER, 1787–1826 (Germany). JNO. HERSCHEL, 1792–1871 (England and S. Africa).	*Wm. Herschel*, by his discovery of BINARY STELLAR SYSTEMS, shows NEWTON'S LAWS to extend throughout the universe. He discovers URANUS in 1781, and by his telescopic researches becomes the pioneer of DESCRIPTIVE ASTRONOMY. *Laplace* summarizes Astronomical Mathematics in his "*Mécanique Céleste*," 1799, and publishes the NEBULAR HYPOTHESIS, 1796.
1800. (George IV. William IV. Victoria.)	LE VERRIER, 1811–1877 (France). ADAMS, 1819–1892 (England). SCHIAPARELLI, 1835–1910 (Italy). SECCHI, 1818–1878 (Italy). HUGGINS, 1824–1910 (England). JANSSEN, 1824–1907 (France). LOCKYER, 1836– (England). VOGEL, 1842–1907 (Germany). E. C. PICKERING, 1846– (America). GILL, 1843– (England and S. Africa).	*Bessel* first MEASURES the DISTANCE OF A STAR by determining the Parallax of *Sixty-one Cygni*, and furthers accurate Astronomy by his Star Catalogue, 1818 founded on *Bradley's* observations. *Jno. Herschel* extends his father's SURVEY OF THE HEAVENS to the S. HEMISPHERE. *Adams* and *Le Verrier* give to gravitational Astronomy its crowning distinction by the THEORETICAL DISCOVERY OF NEPTUNE in 1846. *Draper*, *Bond*, *De la Rue* and *Rutherford* (1840–1864) are pioneers in CELESTIAL PHOTOGRAPHY.
1850. (Victoria.)	YOUNG, 1834–1908 (America). CAMPBELL, 1862– (America). HALE, 1868– (America).	The Science of ASTRO-PHYSICS is established on the interpretation by *Kirchhoff* of the FRAUENHOFER-LINES in the SOLAR SPECTRUM, 1859. *Secchi* forms the first classification of STELLAR SPECTRA in 1863. *Huggins* inaugurates SPECTROSCOPIC PHOTOGRAPHY in 1863 and discovers GASEOUS NEBULAE in 1864. *Janssen*, *Lockyer*, *Young*, *Hale* and *Deslandres* advance SOLAR PHYSICS. *Schiaparelli* demonstrates the CONNECTION between COMETS AND METEORS, 1866, and discovers the MARTIAN "CANALS," 1877. *Vogel* publishes the FIRST SPECTROSCOPIC STAR CATALOGUE in 1883. *Gill* and *Mouchez* inaugurate the INTERNATIONAL PHOTOGRAPHIC CHART of the Heavens in 1887. *Pickering*, *Vogel* and *Campbell* demonstrate SPECTROSCOPICALLY the existence of BINARY STELLAR SYSTEMS.
1900. (Victoria, Edward VII. George V.)		*Vogel* at Potsdam, *Lockyer* at London, and *Hale* at Mount Wilson, affiliate the work of the Astronomical Observatory with that of the Chemical Laboratory in their STUDY OF THE PHYSICAL ELEMENTS OF STELLAR EVOLUTION.

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THE DEVELOPMENT OF ASTRONOMY. By W. ALFRED PARR.

	INSTRUMENTAL.	GENERAL.
ies, is brought to (d. 1476), but the -3.	The instruments known to the Ancients (*e.g.*, The GNOMON, ARMILLARY SPHERE, ASTROLABE, QUADRANT and SEXTANT) continue in use. *Bernard Walther* (d. 1504) introduces the use of CLOCKS in astronomical observations.	During this century Astronomy is still under the INFLUENCE OF GREEK TRADITION, and is at first solely GEOMETRICAL, treating of the motions of the heavenly bodies.
the way for the to Astronomy by ting link between	*Tycho* equips his OBSERVATORY URANIBORG with greatly-enlarged and accurately-divided QUADRANTS and SEXTANTS, and invents the method of sub-dividing the degrees on the arc of an instrument by transversals.	
and the PHASES the foundation of *Fabricius* and nical principles, 1639.	*Hans Lippershey* invents the REFRACTING TELESCOPE in 1608, and *Galileo*, constructing one in 1609 for himself, magnifying thirty-two times, applies the instrument to Astronomy, while *Kepler* improves it in theory. *Hevelius* is the last to make observations without TELESCOPIC SIGHTS, but *Gascoigne* invents the FILAR MICROMETER about 1640, and *Picard* definitely inaugurates the adoption of the TELESCOPE IN CONJUNCTION WITH THE QUADRANT.	Rise of the DYNAMIC CONCEPTION in Astronomy, which after *Galileo* is PHYSICAL, and after *Newton* GRAVITATIONAL, treating of the appearance and mutual attraction of the heavenly bodies.
by constructing he UNIFICATION *Laws* to proceed rms the FIRST	*Huygens* adapts the PENDULUM TO ASTRONOMICAL CLOCKS in 1656, and invents the COMPOUND EYEPIECE, while both he and *Hevelius* improve definition by employing TUBELESS ("AËRIAL") REFRACTORS over one hundred feet long. *Gregory* proposes a form of REFLECTING TELESCOPE in 1663, but *Newton* constructs the first in 1668. *Roemer* invents the TRANSIT INSTRUMENT AND EQUATORIAL, about 1690. PARIS OBSERVATORY erected 1671; GREENWICH OBSERVATORY, 1675.	
OF 1682 makes SOUTHERN STAR F THE EARTH'S	*Graham*, *Bird*, *Cary* and *Ramsden* are the most celebrated constructors of MURAL QUADRANTS about this period.	Rise of DESCRIPTIVE ASTRONOMY and COSMOGONY with *Wm. Herschel* and *Laplace*.
ows NEWTON'S in 1781, and by RONOMY. *este*," 1799, and	*Dollond* invents the ACHROMATIC REFRACTOR, 1758 (suggested by *Hall*, 1733). *Guinand* improves the manufacture of OPTICAL GLASS, 1799, enabling *Fraunhofer* to construct LARGE REFRACTORS. *Wm. Herschel* advances the construction of REFLECTORS and erects his FORTY-FOOT TELESCOPE in 1789.	
the Parallax of Catalogue, 1818, ather's SURVEY *Ferrier* give to AL DISCOVERY in CELESTIAL	*Fraunhofer* applies the SPECTROSCOPE to Astronomy 1815, adapts CLOCK-WORK MOTION to refractors 1824, and erects the FIRST HELIOMETER 1829. *Reichenbach*, *Repsold* and *Troughton* effect IMPROVEMENTS in INSTRUMENT-MAKING early in this century. *Lord Ross* erects his great SIX-FOOT REFLECTOR at Parsonstown, 1845. The first regular observatories of the S. Hemisphere (Paramatta, 1821; Cape, 1829) are founded.	Rise of CHEMICAL ASTRONOMY, after *Fraunhofer*, treating of the composition of the heavenly bodies. Astronomy now gradually widens its sphere and establishes a UNIFICATION OF THE SCIENCES, by extending terrestrial and planetary gravitation to stellar systems, and by showing the essential identity of cosmical matter throughout the visible universe.
irchhoff of the forms the first SPECTROSCOPIC ICS. EOES, 1866, and SPECTROSCOPIC NTERNATIONAL and *Campbell* SYSTEMS.	The first regular application of PHOTOGRAPHY TO ASTRONOMY is made with the *Kew* PHOTOHELIOGRAPH in 1859, but the greatest advances are made after the adoption by *Huggins* in 1876, of the GELATINE DRY PLATE. The ASTRO-PHYSICAL OBSERVATORIES of Potsdam and Meudon, founded 1874 and 1886. The FIRST GREAT REFRACTOR (*Newall*, twenty-five inches), erected 1870; LICK, THIRTY-SIX INCHES, 1888; YERKES, FORTY INCHES, 1897. The EQUATORIAL COUDÉ erected at Paris, 1882. *Chandler* introduces the ALMUCANTAR in 1884. *Hale* devises the SPECTROHELIOGRAPH in 1889. *Turner* introduces in 1895 the COELOSTAT, being a modification of the SIDEROSTAT.	
n, affiliate the oratory in their	The MOUNT WILSON SOLAR OBSERVATORY is established in 1905, and equipped with horizontal and vertical COELOSTAT TELESCOPES, SPECTROGRAPHS, and SPECTRO-HELIOGRAPHS, besides the CHEMICAL AND PHYSICAL APPARATUS OF THE LABORATORY.	

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